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A PILOT STUDY ON THE BIOLOGICAL MONITORING OF WATER QUALITY IN NAMIBIA'S NORTH-EASTERN PERENNIAL RIVERS

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1 INTRODUCTION

1.1 Background

Namibia is the driest country in southern Africa and is consequently depauperate in perennial rivers – with the central regions of the country completely devoid of such features. Around its edges though, and in almost every case forming an international boundary, perennial rivers do exist; from the Orange in the far south to the Zambezi at the very north-eastern tip of the Caprivi region. The knowledge base concerning the functioning, species composition and health of these riverine ecosystems is relatively poor and while a number of focused studies have been undertaken on each of these rivers, there has been no routine regular monitoring of the prevailing water quality or biological health of these systems. It is consequently impossible to state what the environmental health of these systems is now, or how it might change in the future. Without this vital information it is difficult for stakeholders, ranging from individuals to Government Ministries, to make sound decisions for the future sustainable use and protection of these systems. Water is Namibia's most valuable and limiting resource. The pressures on perennial rivers are considerable and will increase exponentially as does the human population and need for resources.

It was with these considerations in mind that the Ecological Research Section of the Division: Water Environment decided to initiate a pilot project designed to investigate the prevailing water quality in the perennial rivers of the Caprivi and Kavango regions (Taylor, 1997). The project was also designed to test, and then suggest modifications to, the methodology already in use for such investigations in South African Rivers. This was done with a view to making recommendations for future monitoring both in the regions studied and the country as a whole. This pilot programme was conceived (Taylor, 1997) and co-ordinated by Dr. Eliot Taylor who has extensive experience in the field of biological monitoring programmes in the UK, where the methodology originated.

1.2 Rationale

Over the last 15 years, some basic water chemistry data have been collected from the rivers and floodplains of the eastern Caprivi and the Okavango River. These data have been collected for use in the control of *Salvinia molesta* project (Bethune, 1996) and as part of a baseline survey of the Okavango River in Namibia (Bethune, 1987; Bethune, 1991). The analyses performed are, however, of limited use in long-term determination of water quality and detection of pollution. More detailed chemical analysis is often very expensive, particularly if the presence of certain pollutants, e.g. pesticides or of a specific chemical make-up, e.g. nutrients content, are required. Detection of pollution by chemical sampling is also problematic if the polluting source is intermittent in nature. For example, a water sample may be taken on a particular day and time whereas the pollution may have occurred several hours beforehand and been washed away or occur after sampling. Use of biological indicators, however, gives a picture of the long term prevailing water quality in any watercourse and is thus considered a more reliable measure. Pollution in rivers can be detected relatively easily, quickly and cheaply by looking at indicators based on biological characteristics and, in particular, at the macroinvertebrate fauna. Routine sampling of macroinvertebrates in flowing water, as a method of assessing changes in water quality is well established in Europe, the USA and more recently Australia. This methodology can be used to detect changes caused either directly as a consequence of chemical or biological pollution or indirectly as a consequence of physical perturbations such as reduced flows. The information gained about river systems using such methods is very valuable. Temporal changes in invertebrate fauna at a single monitoring site or spatial differences between the faunas of impacted and un-impacted sites can be easily seen. The ideal use of such monitoring, but one which is rarely available, is the ability to refer to the pre-impacted state, that is to say what the invertebrate fauna was like before the river was noticeably affected by the actions of man. Collection and collation of such information assists stakeholders to gauge just how far a river has changed from its original state and what remedial measures might be made to help the river to return to, or approach, this. Using biological information in this manner is often not possible because regular monitoring only began after the rivers began to change. This is true to some extent with Namibia's rivers (particularly those in the Caprivi) but less so than for most of the systems in which the methodology is in use in the UK and South Africa. Namibia thus has a unique chance to use the methodology in its most appropriate fashion.

An empirical biotic index to measure the quality of water in South African streams and rivers was devised by Chutter (1972); this was similar to the Biological Monitoring Working Party (BMWP) scoring system (Chesters, 1980; National Water Council, 1981) used in the UK. Both systems work in the same way but the scoring system has been changed for the South African version. Two main changes have been made, comprising a change in the list of taxa used for the BMWP system and a change in scores allocated to taxa. In the BMWP system scores ranged from 1-10 for each scoring taxon but in the SASS system this was changed to 1-15. These changes were made to reflect the difference in the type of fauna found on the African continent and to broaden the possible scoring band; that of BMWP was perceived to be too narrow. After much development (Chutter, 1992; Chutter & Geuppert, 1993; Chutter, 1994a; Chutter, 1994b: Chutter, 1998) an index, now known as the Southern African Scoring System, version 4 (SASS4), was established in South Africa. This has undergone extensive testing and it is a modification of this that we wish to develop and use now in Namibia.

2 MATERIALS AND METHODS

2.1 The study sites

The pilot programme research was restricted to the north-eastern perennial rivers of Namibia, namely the Okavango, Kwando, Zambezi and Chobe systems. Sampling sites were chosen for their ease of access and in order to sample the most productive parts of the rivers, i.e. fast flowing water over a stony substratum (rapids) where this occurred. Two sites were chosen on each river system, where possible. Information about these sites is given in Tables 1&2 and Figure 1.

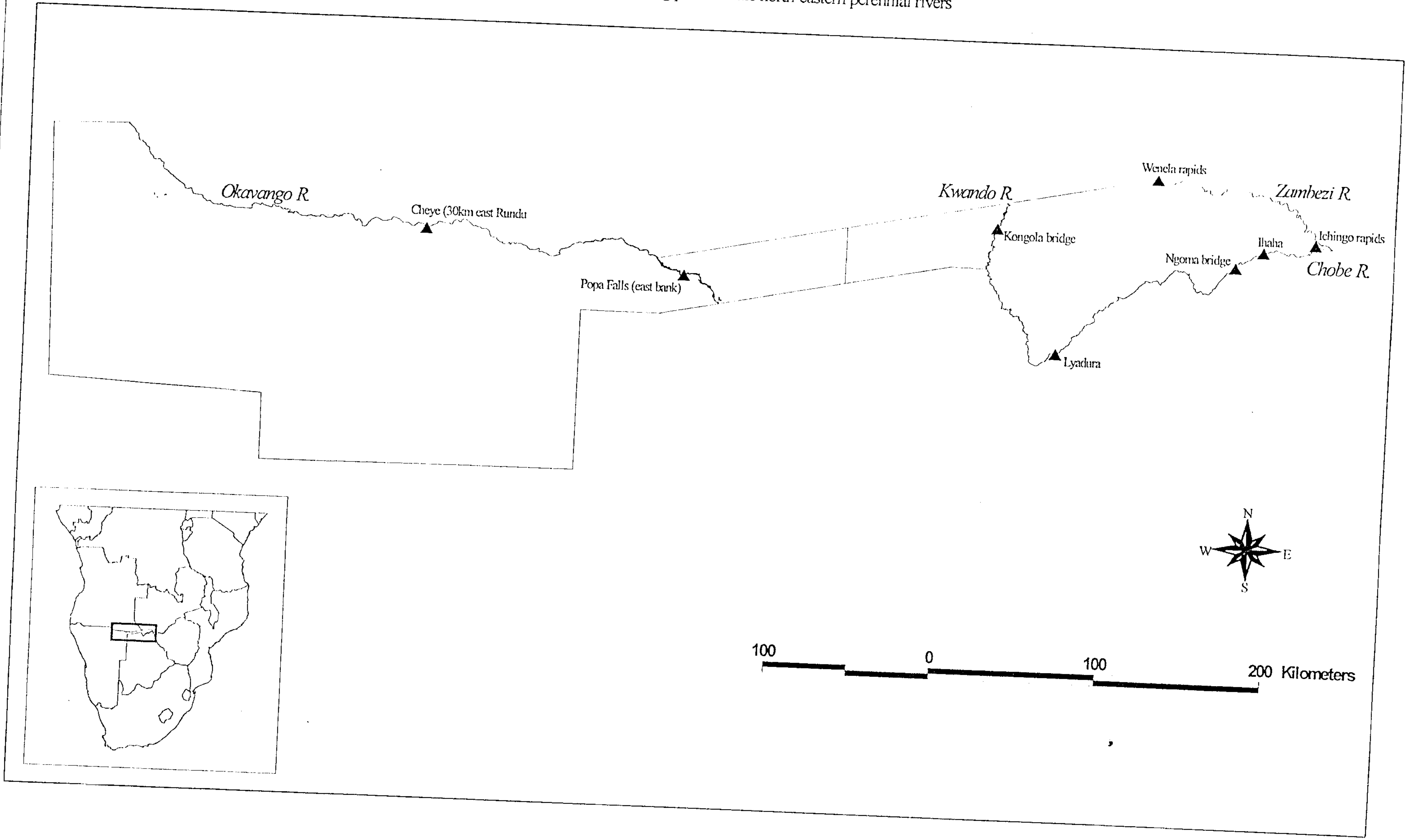
2.2 Sampling strategy

The first step in the process is to choose sites where water quality needs to be determined. This will often be downstream of a perceived factor that may influence the water quality standard, e.g. a sewage outfall, a dam etc. Sampling here will help to determine the degree to which the factor is impacting the riverine environment. Other sites, known as reference sites, where there is no perceived impact on the water quality, are also sampled for comparison with impacted sites. Macroinvertebrates are collected from all the main hydrogeomorphological or biological habitats available at any designated sampling point e.g. rapids, sand bars, submerged and emergent vegetation. This is done as different families have different bio-physical requirements and preferences as to where they live. Some macroinvertebrate families prefer slow flowing, non-turbulent water with weeds where they can hunt for their prey e.g. many Dragonfly larvae (Odonata). Others prefer fast flowing, shallow water with a turbulent flow and high dissolved oxygen content where they can respire and graze algae from the surface of stones e.g. Mayfly larvae (Ephemeroptera).

Table 1 **Sampling sites**

River name	Site name	GPS reading	
Okavango	Cheye (30km's east Rundu)	17 54 641	20 06 311
	Popa Falls (east bank)	18 06 692	21 34 950
Kwando	Kongola bridge	17 47 200	23 21 100
	Lyadura	18 26 001	23 43 047
Zambezi	Wenela rapids at border post	17 28 530	24 14 882
Chobe	Ngoma bridge	17 55 274	24 43 222
	Ihaha	17 49 965	24 52 375
Chobe/Zambezi	Ichingo rapids at Impalila	17 46 584	25 09 992

Figure 1 SASS sampling points in the north-eastern perennial rivers



The main habitats described in the SASS technique comprise:

- Stones in Current (SIC)
- Stones out of Current (SOOC)
- Aquatic (submerged or floating) vegetation (AV)
- Marginal (Emergent) vegetation (MV)
- Sand
- Silt/Mud

The SIC and MV habitats have proved to be the most common and important in terms of the number of taxa they yield (Chutter, 1998) and at least one of these two habitat types should be included at any sampling point. Each habitat is sampled for a set length of time using a standard collecting technique and a collecting net of a stipulated mesh size. Samples are then sorted and a single representative of each taxonomic group is found, kept and identified, usually to family level. The system used to determine water quality relies on the differing physiological response of different invertebrate taxa to changes in water quality. Some families, such as the Ephemeroptera, that most commonly occur in fast flowing, well oxygenated water, can only tolerate small changes in water quality. This is particularly true if the pollution is organic in nature and/or results in a reduction in the amount of dissolved oxygen available. Families such as Ephemeroptera are allocated the highest score (15) to indicate that they are pollution intolerant organisms. Other family groups, such as freshwater worms (Oligochaeta), can tolerate much greater changes in water quality as their bodies contain haemoglobin and are able to survive even with very low levels of dissolved oxygen. Such families are allocated the lowest score (1) to indicate that they are pollution tolerant.

The majority of common freshwater invertebrate family groups have been allocated their own score (from 1-15) depending on their response to pollution. Water quality is determined in three main ways from the combination of these scores. The first of these is the total, or SASS, score and is determined by the addition of all scores from each scoring taxonomic group. This score is affected, not only by the water quality but also by the habitat at the site. For example, a site with five different habitat types will score more highly than one with only two, even if the water quality is the same at both. For this reason a second score is also determined, which is the Average Score Per Taxon (ASPT). This is determined by dividing the SASS score by the number of scoring taxa found. The use of ASPT scores reduces, to some extent, the influence of habitat and gives a more reliable measure of water quality. The final score that can be determined from this sampling method and which may reflect on water quality is the Number of (scoring) Taxa (NoT) found at a site. In certain conditions, e.g. in naturally acidic waters, the invertebrate fauna is composed of a low number of high scoring taxa. The ASPT for such sites is thus naturally high and pollution in such waters may be hidden by use of the SASS score and ASPT alone. Analysis of all three scores gives the most information about water quality and is the most effective way of using the data obtained. The SASS score tends to impart more information when habitat diversity is low or when water quality is poor, whereas ASPT tends to be the more reliable measure when habitat diversity is high and water quality good (Chutter, 1998).

Table 2 List of habitat types sampled at all sampling sites

Site	Date	SIC	SOOC	MV	AV	SAND	SILT/MUD
Cheye	2/6/97	#			#		
	28/7/97	#	#		#		
	6/10/97	#	#		#		
	4/12/97	#	#		#		
	2/2/98			#			
	31/3/98			#			
	1/6/98			#	#		
Popa	13/2/97	#		#		#	
	2/6/97	#		#		#	
	28/7/97	#		#		#	
	6/10/97	#		#		#	
	4/12/97	#		#		#	
	2/2/98	#		#		#	
	31/3/98			#			
	1/6/98	#		#		#	
Kongola	10/2/97	#		#			
	27/5/97	#		#	#		
	24/7/97	#		#	#		
	1/10/97	#		#	#		
	5/12/97	#		#	#		
	3/2/98	#		#	#		
	1/4/98	#		#	#		
	2/6/98	#		#	#		
Lyadura	11/2/97			#	#		
	25/3/97				#		
	28/5/97			#	#		#
	24/7/97			#	#		#
	2/10/97			#	#		
	5/12/97			#			
	3/2/98			#	#		
	1/4/98			#	#		
	2/6/98			#	#		
Ngoma	29/5/97			#			
	23/7/97			#			
	30/9/97			#			
	3/12/97			#			
	4/2/98			#			
	30/3/98			#			
	1/6/98			#			
Ihaha	4/2/97			#			
	25/5/97			#			
	23/7/97			#			
	30/9/97			#			
	3/12/97			#			
Ichingo	7/8/97	#			#		
	5/2/98	#			#		
	24/7/97	#			#		
	2/4/98				#		
	4/6/98	#			#		
Wenela	3/5/97	#		#	#		
	8/8/97	#		#			
	30/9/97	#		#			
	3/12/97	#		#			
	4/2/98	#		#			
	8/4/98			#			
	3/6/98	#		#			

2.3 Sample site descriptions

2.3.1 Okavango River

2.3.1.1 Cheye

The river here was *circa* 100m wide. In the dry season the marginal vegetation (MV) habitat, comprised mostly of reeds *(Phragmites mauritianus)* and sedges *(Carex* spp.*)* was left dry by the dropping water level. The aquatic vegetation (AV) habitat was composed almost completely of floating pondweed (*Potamogeton thumbergii*) with the occasional plant of willow-herb (*Ludwigia stolonifera*). The stones in current (SIC) habitat was characterised by large boulders of silcrete interspersed with smaller rocks, pebbles, gravel and sand of the same material; the flow of water over this was fast and turbulent. The stones out of current (SOOC) habitat was characterised by small, smooth pebbles embedded into a sandy substratum with the occasional frond of *Potamogeton thumbergii* also occurring. In the flood season the marginal vegetation habitat was inundated and the only habitat available for sampling in February; by March the AV habitat was also exposed.

2.3.1.2 Popa

The river here was *circa* 500m wide and consisted predominantly of outcropping bedrock, forming rapids. In the dry season the MV habitat on the left bank, comprised mostly of rushes, was left dry by the dropping water level. MV could, however, be sampled on a small island when the water level was low enough, the vegetation here was comprised of hippo grass *(Vossia cuspidata)*. There was no AV habitat available here. The SIC habitat was characterised mostly by bedrock silcrete with the occasional smaller boulder; the flow of water over this was fast and turbulent. The Sand habitat was characterised by patchy and small sand bars on the downstream side of rocky outcrops and boulders. In the flood season only the MV habitat on the left bank was available for sampling and was covered in a thick growth of blanket weed, thought to be the blanket-weed algae, *Cladophora* spp.

2.3.2 Kwando River

2.3.2.1 Kongola

The river here was *circa* 15m wide. MV habitat was available all year round and was comprised of hippo grass *(Vossia cuspidata)*. The AV habitat was also available all year and composed of floating pondweed (*Potamogeton thumbergii*). The SIC habitat was characterised mostly by small rocks, pebbles, gravel and sand and the flow of water over this was fast but predominantly laminar. No noticeable flooding occurred in this river with all habitats available for sampling year round.

2.3.2.2 Lyadura

The river here was *circa* 20m wide, slow flowing and with no SIC habitat present. The riverbed was composed entirely of silt with the main habitats, MV, consisting of sedges (*Carex* spp.) and AV, consisting of willow-herb (*Ludwigia stolonifera*), floating water-fern (*Salvinia molesta*), water lilies (*Nymphaea* spp.) and floating pondweed (*Potamogeton thumbergii*), available year round. The river here was deep and turbid, sampling was carried out from the left-hand bank only.

2.3.3 Chobe River

2.3.3.1 Ngoma

The sample site here consisted of a *circa* 20m diameter, 3-4m deep pool of standing water in the riverbed for the majority of the year. The MV habitat was composed of fringing hippo grass (*Vossia cuspidata*) from where most samples were taken. In February and March 1998 the river filled with water as the Zambezi flooded. Water was flowing upstream (in an easterly direction) in February but had reversed its flow and was flowing downstream (in a westerly direction) at the end of March. Samples were taken from inundated floodplain grasses on both occasions.

2.3.3.2 Ihaha

The river here was *circa* 15m wide, not flowing, with a silt/mud substratum. The MV habitat consisted of sedges (*Carex* spp.) and hippo grass (*Vossia cuspidata*), the AV habitat of fine oxygen weed (*Largarosiphon* spp.), floating water-fern (*Salvinia molesta*), bladderwort (*Utricularia* spp.), saw weed (*Najas* spp.) and lilies (*Nymphaea* spp.). Although the river at this point appeared to be a continuous channel it was difficult to say if it had a direct hydraulic connection with the main channel at Kasane. During the flood season, in February and March, it was impossible to reach anywhere near this site and no samples were taken during this time.

2.3.4 Chobe / Zambezi River

2.3.4.1 Ichingo

The river here was *circa* 500m wide and consisted predominantly of outcropping bedrock, forming rapids. Due to its distance from Katima and the difficulties in accessing the site it was only visited on four occasions. In August 1997 MV, consisting of hippo grass (*Vossia cuspidata*), papyrus (*Cyperus papyrus*), AV, consisting of an unidentified submerged macrophyte growing on a sand bar and SIC (mostly bedrock silcrete with the occasional smaller boulder) habitats were available. The flow of water over the latter was fast and turbulent. In February, March and June 1998 only recently inundated unidentified riverbank grasses (MV), AV of blanket-weed (*Cladophora* spp.) and bedrock (SIC) were available for sampling.

2.3.5 Zambezi

2.3.5.1 Wenela

The river here was *circa* 500m wide and consisted predominantly of outcropping bedrock, forming rapids. SIC habitat was comprised of this bedrock with some moveable small boulders, rocks and pebbles; the flow over this was fast and turbulent. MV habitat consisted of a floating raft of hippo grass (*Vossia cuspidata*) over water in a still pooled section of the river. The SOOC habitat was found to the side of the main channel when the water level had dropped low enough to leave a "rock pool". During the floods, samples were taken from recently inundated bedrock on the riverbank and, once the full flood arrived, from inundated unidentified riverbank grasses only.

2.4 Methodology

2.4.1 Sampling

Heavy duty rubber waders were worn for all sampling in order to protect the sampler from bilharzia infection, particularly in the Kwando River, and from the very rough surfaces of the bedrock occurring in the study rivers. The sample net used was smaller in area than that suggested in the SASS4 methodology but of the specified mesh (*circa* 1mm). The net used was one used as standard in BMWP sampling in the UK and although of a smaller area this was unlikely to have seriously affected the SASS, NoT and ASPT scores acquired during the study (Chutter, personal communication, June 1998). Spotters, staff members positioned at strategic positions on the bank and in the river, were used to check and watch for crocodiles both before and during sampling. The choice of sample sites was restricted both by ease of vehicular access to the site and by the safety aspects of sampling, e.g. no samples were taken by wading in water deeper than knee deep, particularly if the water was turbid. This restricted the number of types of habitat that might have otherwise been available, e.g. silt/mud, SOOC.

2.4.1.1 Stones in Current (SIC)

This habitat was sampled by kick sampling. This involved standing with the sample net on the downstream side of the sampler whilst the riverbed was disturbed by shuffling movements of the feet, designed to overturn rocks and dislodge invertebrates. The net was held firm against the riverbed and the current washed bed material and any macroinvertebrates into the net. This process was done for a timed period of two minutes where there were rocks that could be dislodged. On impacted substrata or on solid bedrock the sampling was done for five minutes.

2.4.1.2 Aquatic vegetation (AV) and marginal vegetation (MV)

These habitats were sampled by sweeping the collecting net in and out of (MV), or through (AV), macrophytes. The action was designed to create a current, as well as physical disturbance, that dislodged macroinvertebrates living in these substrata and washed them into the collecting net. Care was taken to collect as little as possible of the actual macrophytes being sampled, as large quantities of debris made the sorting process more complicated. This sampling was done for two minutes in each habitat.

2.4.1.3 Stones out of current (SOOC), Silt and Sand

These habitats were sampled by combining the techniques described in the previous two sections. The substrata was disturbed by shuffling movements of the feet whilst the net was swept through the dislodged sand, mud or stones in order to collect the macroinvertebrates. Stones out of current were sampled by area, with *circa* $1m^2$ being sampled, whilst the other habitats were sampled for *circa* 30 seconds.

2.4.2 Sorting

All samples were emptied from the sampling net into a large (*circa* 40x30x10cm) white plastic tray on the bank. The tray was positioned in such a way as to ensure that it was both level and to enable the operator to be comfortable while sorting. A small quantity of water was added to the sample and single specimens of all the different groups seen were removed and placed in a 60ml plastic pot containing 70% industrial methylated spirit (IMS) or a similar preservative. Large pieces of debris were removed from the tray, carefully inspected for macroinvertebrates, and thrown out – this enabled other invertebrates to be more easily seen. Once no new taxa could be seen the small sample pot was plugged with a small wad of cotton wool, to prevent mechanical damage of the specimens during transport, and sealed. The main sample was drained of water, tipped into a large container and a 4% formaldehyde solution added; this container was then also sealed. All samples were then returned to the laboratory where they underwent a through second sorting under standard conditions, e.g. comfortably seated worker, bright light source and laboratory conditions. No time limit was set for this re-sort with the material being disposed of only after the complete sample had been thoroughly rechecked for any further taxa; these were then added to the appropriate original 60ml vial.

2.4.3 Identification

For the purpose of the SASS methodology identification need only be made, in most instances, to the family level. As little work has been done on these rivers previously, and as a potential contribution to the biodiversity knowledge base in Namibia, taxa were identified to lowest possible taxonomic level for this study. In some instances this was restricted by the scant knowledge and taxonomic keys available. Keys were obtained from those published in the UK and from a collection of mostly unpublished works held at the University of Cape Town. The ones used were those of Wilmot, Van Eeden (1960), Appleton (1996), Elliott & Mann (1979), Henning, Hart & Bickerton, Scott (a-d), McCafferty (1990), Barber (1985), Enrody-Younga *et al* and de Moor. Specimens were identified under a x8 – x40 binocular Nikon dissecting microscope with an external 150W cold light source. Voucher specimens were made and sent to the National Museum of Namibia for registration, confirmation and storage.

2.4.4 Data Collation

At each sample site a field check sheet was filled in, recording details of the site location, the habitats sampled, date of sample etc., an example of this is shown in Appendix X. Once the sample had been sorted each of the scoring taxa, from each habitat, were recorded next to the appropriate name on the checklist. A measure of the numerical abundance of each taxon was made where 1-10 individuals was donated A, 11-100 B, 101-1000 C and 1000+ D. The SASS score, the ASPT and the NoT were calculated and recorded for each habitat type. The total score for the whole site was then also calculated – this was done by combining the taxa found from each habitat type and not by adding each score. For example, if the mayfly Heptageniidae was found in the SIC, SOOC and MV habitats at a site it was recorded as having occurred only once in the total score whereas the scores associated with taxa unique to each habitat type were added together in the total. See data sheets in Appendix X for examples. The SASS, ASPT and NoT scores were all recorded in a database for future processing and comparisons.

2.5 Hydrology

One parameter which was measured in all the river systems was the stage height in the river, as determined by readings from the nearest gauge plate, on each sampling occasion. This reflected the state of the flood in the river system and appeared to represent the single biggest changeable factor at the majority of sample sites. Figures 2 & 3 show the change in water level at the gauge plate nearest to each sampling site throughout the study period.

Figure 2 Gauge plate reading for Rundu, Mohembo and Katima Mulilo during the study period

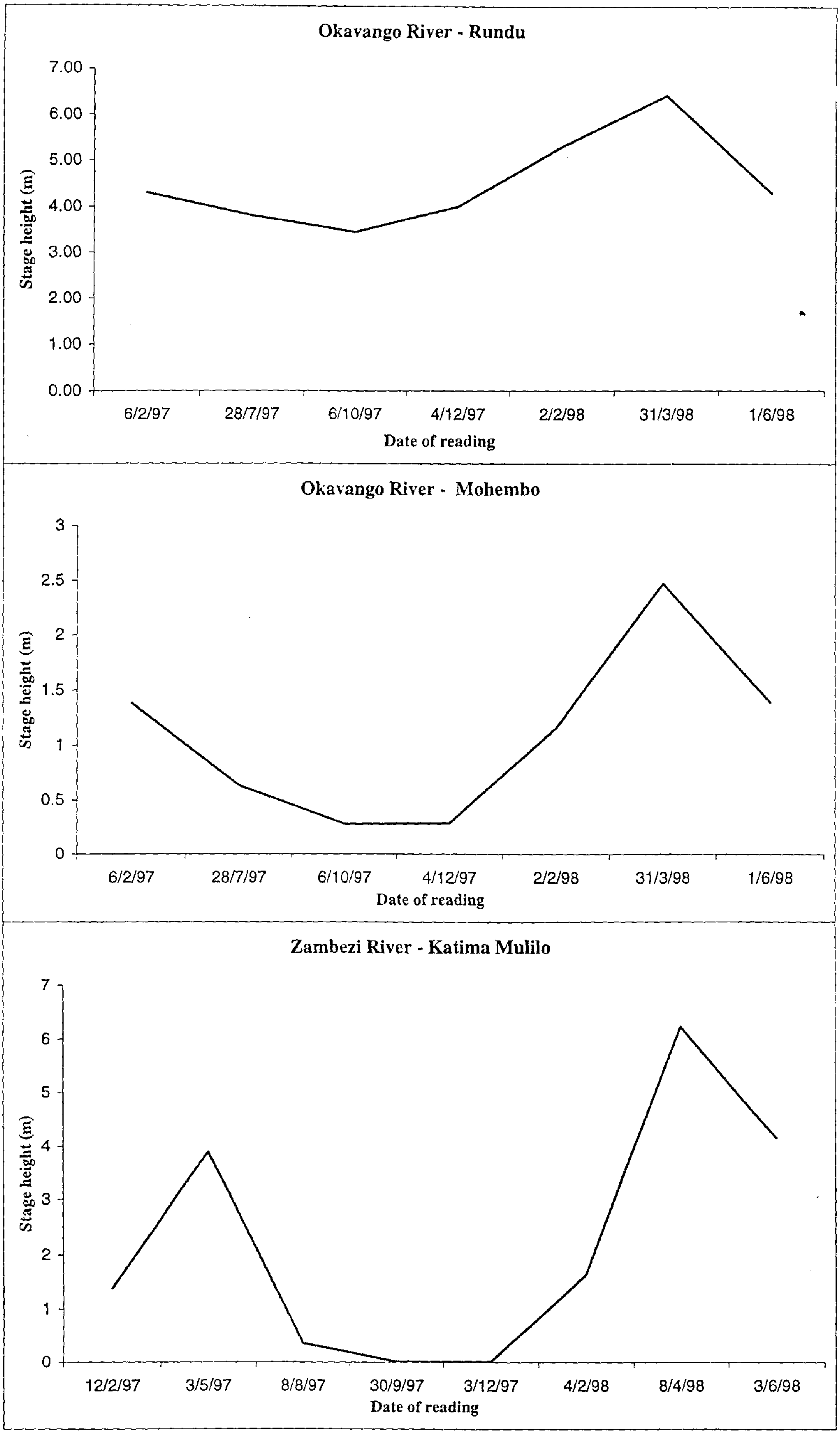
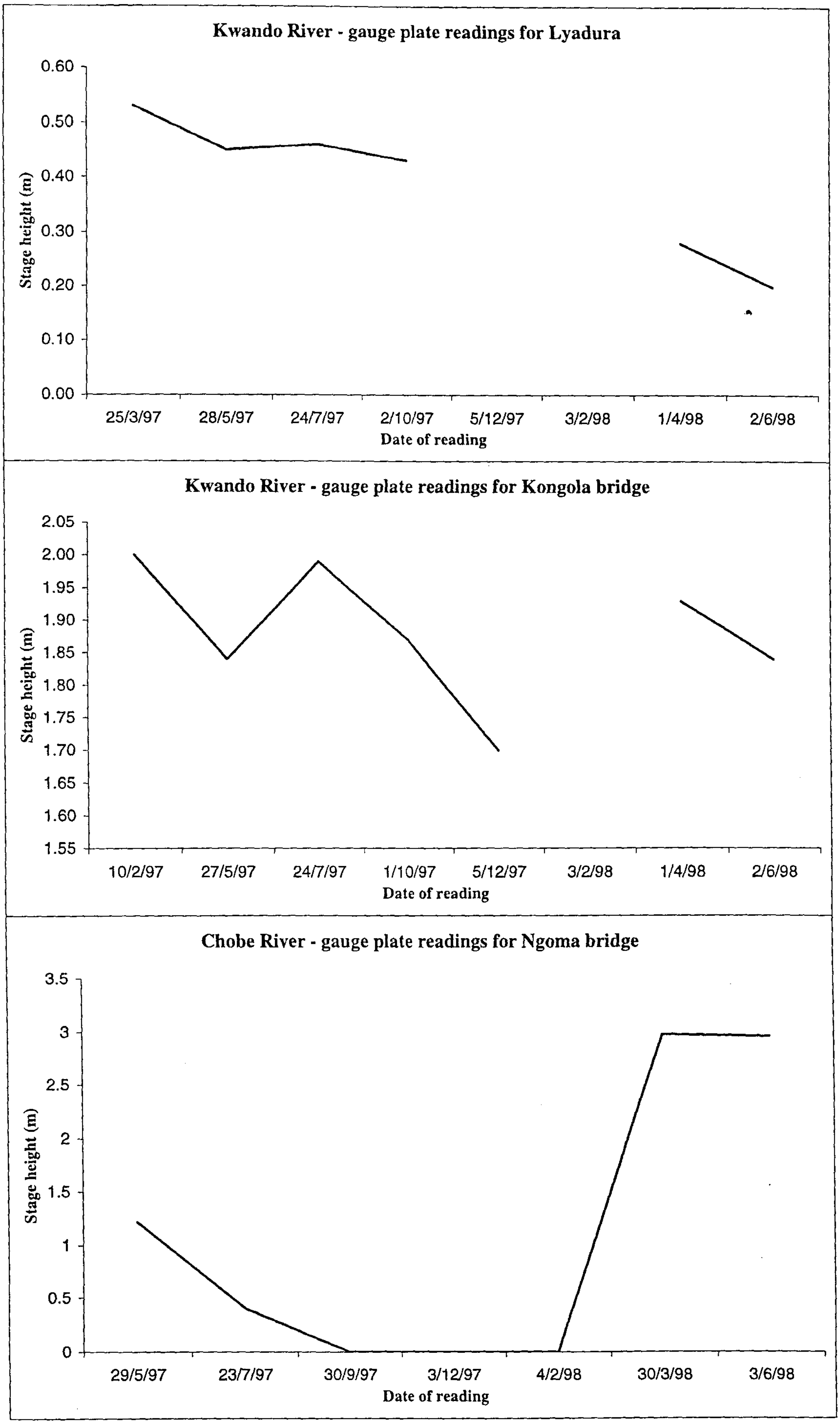


Figure 3 Gauge plate readings for Lyadura, Kongola and Ngoma during the study period



3 RESULTS AND DISCUSSION

3.1 Preliminary work

Before this baseline study began, Dr. Chutter (the researcher who developed the SASS technique) carried out a consultancy on the applicability of the SASS4 method for the assessment of water quality in Namibia's north-eastern perennial rivers. During this study 12 sites were visited on four rivers in the Okavango and Caprivi regions, samples were taken, analysis carried out and recommendations made (Chutter, 1997). The following are some of the conclusions made from that study:

- It is necessary to undertake a baseline study of the seasonal variation in the composition of invertebrate communities in the study area.
- The standard SASS4 score sheet should be modified to take account of the invertebrate communities in the rivers in the study area.
- The SASS4 technique "works" in the study area.

In another report (Chutter, 1998) recommendations were made for the interpretation of SASS4 data collected in South Africa and the interpretation of SASS, NaSS and ASPT scores in this discussion was based on the information given in that report. In the paper he stated that:

"Where Southern African waters are not naturally acid (pH > 6)......guidelines for the interpretation of scores should be as follows:

SASS4 > 100, ASPT > 6 – water quality natural, habitat diversity high

SASS4 < 100, ASPT > 6 - water quality natural, habitat diversity reduced

SASS4 > 100, ASPT < 6 – borderline case, possibly some water quality deterioration

SASS4 50-100, ASPT < 6 – some deterioration in water quality

SASS4 < 50, ASPT variable -- major deterioration in water quality

These boundaries for interpretation are artificial boundaries in a continuum, which is why they should be used as guidelines"

The rivers in the study area were all thought to be of pH 6 or higher and despite the addition of some new, and the removal of other existing taxa, these guidelines stood for the interpretation of SASS/NaSS scores from Namibian rivers as well.

Chutter (1998) also suggested that although all possible habitats at a particular site should be sampled, the most important of these were SIC and MV habitats. If either or both of these were present at a site and sampled then this would give a sufficient idea of the water and habitat quality there. If other habitats alone were sampled then water quality could be still be determined but the SASS score would be reduced reflecting the restricted habitats sampled.

3.2 Development of a Namibian Scoring System – NaSS

During the course of this study eight families were found that did not appear in the existing SASS4 list of taxa, these were assigned scores (in consultation with Dr. Chutter) and added to the existing list. In the following sections scores are shown for both the original SASS system and for the additional taxa found in Namibia, this is referred to as NaSS or the Namibian Scoring System. The additional taxa found and the scores assigned to then are shown in Table 3.

Table 3 **List of additional taxa**

Phylogeny	Species occurring	Score
Gastropoda		
Ampullariidae	*Lanistes ovum* *Pila occidentalis*	3
Viviparidae	*Bellamya capillata*	6
Thiaridae	*Melanoides* spp. *Cleopatra* spp.	3
Bithyniidae	*Gabiella kisalensis*	3
Corbiculidae	*Corbicula fluminalis*	3
Insecta		
Sisyridae	*Sisyra* spp.	4
Noteridae	*Canthydrus* spp.	5
Curculionidae	*Cyrtobagous salviniae* Genus and species indet.	5

In addition to taxa found that had not previously been recorded there were other taxa that had been recorded in South Africa but that were not found in any of the samples taken during this study. Addition of these new taxa to the original SASS4 checklist and the removal of the taxa not found led to the creation of a new checklist, referred to as the Namibian Scoring System – version 1 (NaSS1) and this is shown in Table 5.

In the following sections it can be seen that addition of these "Namibian" taxa to the existing SASS list invariably increased both the total (SASS and NaSS) score and the Number of

Table 4 **NaSS Biological Monitoring Sheet**

River________________________ Date________ Sampling point________________________

Biotopes sampled: Temp_____ pH_____ Cond_______

SIC___Type / Time________________ Marg Veg___Species________________ Aq. Veg___Species________________

Mud/Silt___ Gravel____ Other____ SOOC___ Sand___

Taxon	Score	Habitats			all
Porifera	5				
Coelenterata					
Hydra spp.	1				
Turbellaria					
Planarians	5				
Annelida					
Oligochaeta	1				
Hirudinea					
Leeches	3				
Crustacea					
Crabs	3				
Shrimps	8				
Hydracarina					
Hydrachnellae	8				
Plecoptera					
Perlidae	12				
Ephemeroptera					
Polymitarcidae	10				
Baetidae 1 sp.	4				
2 spp.	6				
> 2 spp.	12				
Oligoneuridae	15				
Heptageniidae	10				
Leptophlebiidae	13				
Tricorythidae	9				
Prosopistomatidae	15				
Caenidae	6				
Odonata					
Coenagriidae	4				
Chlorocyphidae	10				
Zygoptera juvs.	6				

Taxon	Score	Habitats			all
Gomphidae	6				
Aeshnidae	8				
Corduliidae	8				
Libellulidae	4				
Hemiptera					
Belastomatidae	3				
Notonectidae	3				
Naucoridae	7				
Nepidae	3				
Corixidae	3				
Gerridae	5				
Veliidae	5				
Neuroptera					
Sisyridae	4				
Trichoptera					
Hydropsychidae 1 sp.	4				
2 spp.	6				
> 2 spp.	12				
Philopotamidae	10				
Ecnomidae	8				
Hydroptilidae	6				
Cased caddis: 1 case, 1 family	8				
2 cases, 1 family	15				
3 cases, 1 family	20				
4 cases, 2 families	30				
5 cases, 2 families	40				
> 5 cases, 3 families	50				
Lepidoptera					
Nymphulidae	15				
Coleoptera					
Dytiscidae	5				

Taxon	Score	Habitats			all
Elmidae/Dryopidae	8				
Curculionidae	5				
Gyrinidae	5				
Noteridae	5				
Hydrophilidae	5				
Diptera					
Culicidae	1				
Simuliidae	5				
Chironomidae	2				
Ceratapogonidae	5				
Tabanidae	5				
Gastropoda					
Lymnaeidae	3				
Thiaridae	3				
Viviparidae	6				
Ampulariidae	3				
Bithyniidae	3				
Ancylidae	6				
Planorbidae	3				
Hydrobiidae	3				
Pelecypoda					
Corbiculidae	3				
Unionidae	6				
SAMPLE SCORE (NaSS)					
NUMBER OF SCORING TAXA					
ASPT					

Other taxa found, notes, comments

Scoring Taxa (NoT), but decreased the ASPT. This effect was a function of the low scores of the new taxa (the maximum being 6 for Viviparidae) and the fact that in most cases only one or two new species occurred at any one site.

The addition of only one or two low scoring taxa thus reduced the overall ASPT. In many cases the only taxon added was that of Corbiculidae, a very similar family to the Sphaeriidae that appears on the SASS4 checklist. Save for this slight difference in the family of pea mussel that occurred in the sample area, SASS and NaSS scores would actually have been the same in many cases. The slightly lower scores observed for NaSS were not attributable to pollution in the rivers studied.

The majority of the new families found during the study were low scoring taxa, mostly from the order Gastropoda. The lack of additional high scoring taxa may have been related to the more tropical nature of the study rivers. The water temperatures in the sample rivers were relatively high during the summer months (*circa* 25+°C) and oxygen levels were likely to have been relatively low. The fauna occurring in the area is thus one comprised of a larger number of taxa pre-adapted to periods of depleted dissolved oxygen (DO), e.g. many species of Gastropoda are able to obtain air directly from the water surface if needs be. This attribute led them to be classified as less sensitive organisms and thus given a low score, e.g. 3 for the majority of the snail families. High scoring taxa, more sensitive to changes in DO, are probably less common in Namibia's northern rivers than elsewhere in southern Africa and consequently no new high scoring families were recorded during this research.

3.3 Monitoring results

3.3.1 The Okavango River

3.3.1.1 Cheye

Four different habitat types were sampled at Cheye: Aquatic Vegetation (AV), Stones Out Of Current (SOOC), Stones In Current (SIC) and Marginal Vegetation (MV). Not all of these were available for sampling the whole year round. AV was only available for the first four and last month of the study, SIC only available for the first four months, SOOC only for the second to fourth months inclusive and MV only for the last three months. The availability of habitats was determined entirely by the volume of water in the river in any month, e.g. AV and SIC were inundated beyond sampling depth by February 1998 whereas MV didn't have enough water to warrant sampling until the same month.

The list of taxa for the SIC habitat at Cheye is shown in Table 1 in Appendix I. The scores from this habitat are shown in Table 5 and represented graphically in Figure 4.

Figure 4 Graphs showing scores from the SIC habitat at Cheye

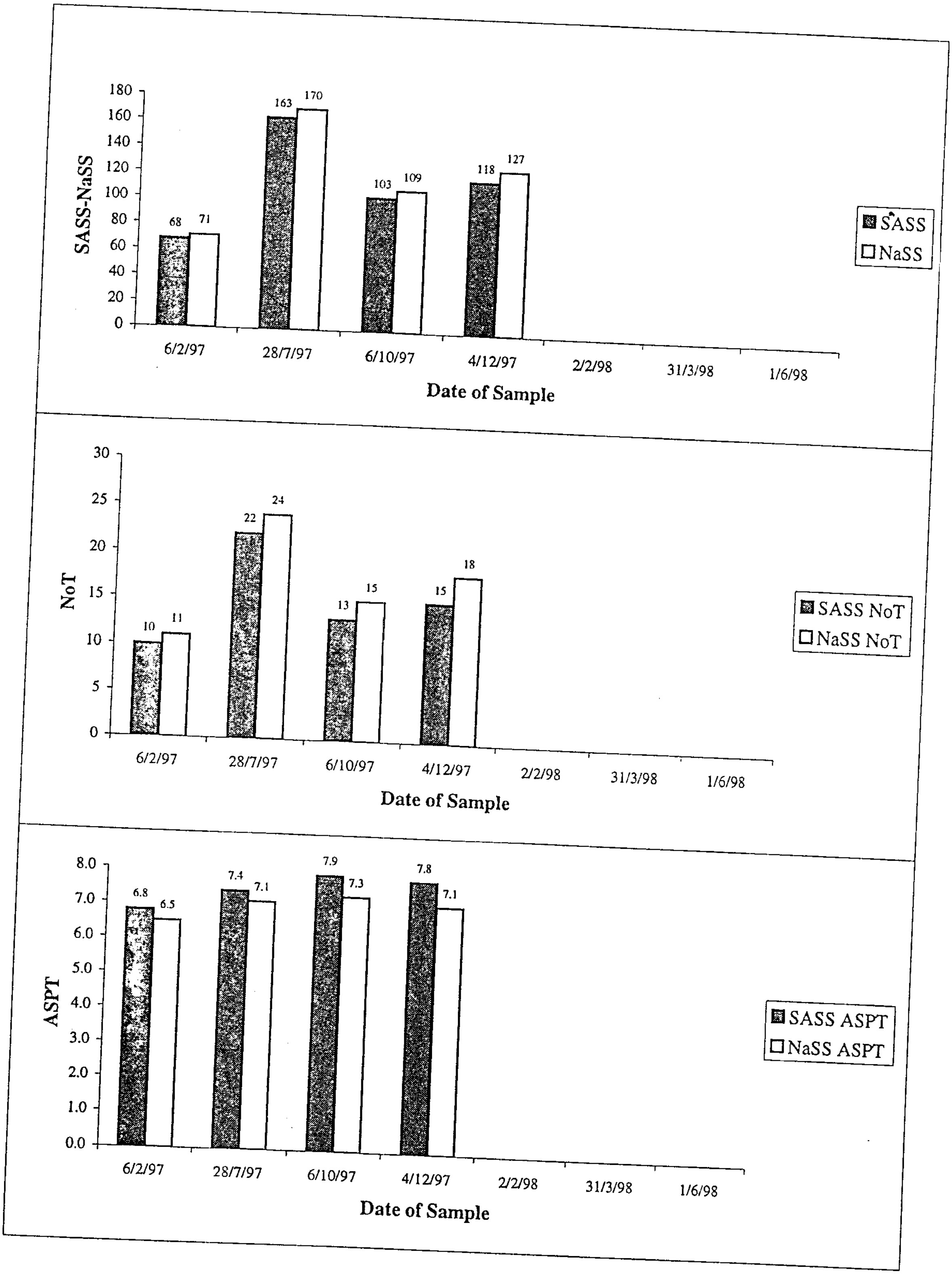


Table 5 Water quality scores for Cheye – Stones in Current habitat

Date	SASS Score	SASS NoT	SASS ASPT	NaSS NoT	NaSS Score	NaSS ASPT
2/6/97	68	10	6.8	11	73	6.5
28/7/97	163	22	7.4	24	169	7.1
6/10/97	103	13	7.9	15	109	7.3
4/12/97	118	15	7.8	18	127	7.1
2/2/98	-	-	-	-	-	-
31/3/98	-	-	-	-	-	-
1/6/98	-	-	-	-	-	-

Monthly changes in SASS/NaSS and NoT in the SIC habitat were somewhat erratic, being low one month and high the next. The lowest score was recorded in June 1997 just after the flood had subsided. Scores were then generally much higher as the water level dropped and just as it began to rise again in December 1997. The changes in SASS/NaSS and NoT scores obtained from month to month were thought to be related to a combination of seasonal changes in the invertebrate fauna and the ability to reach different parts of the SIC habitat in different months. ASPT scores for SIC showed the same trend as for the AV habitat, increasing from June to October and then dropping slightly as the river began to rise again in December 1997. ASPT scores were all >6.0 and the majority of SASS/NaSS scores were above 100 reflecting excellent habitat and water quality.

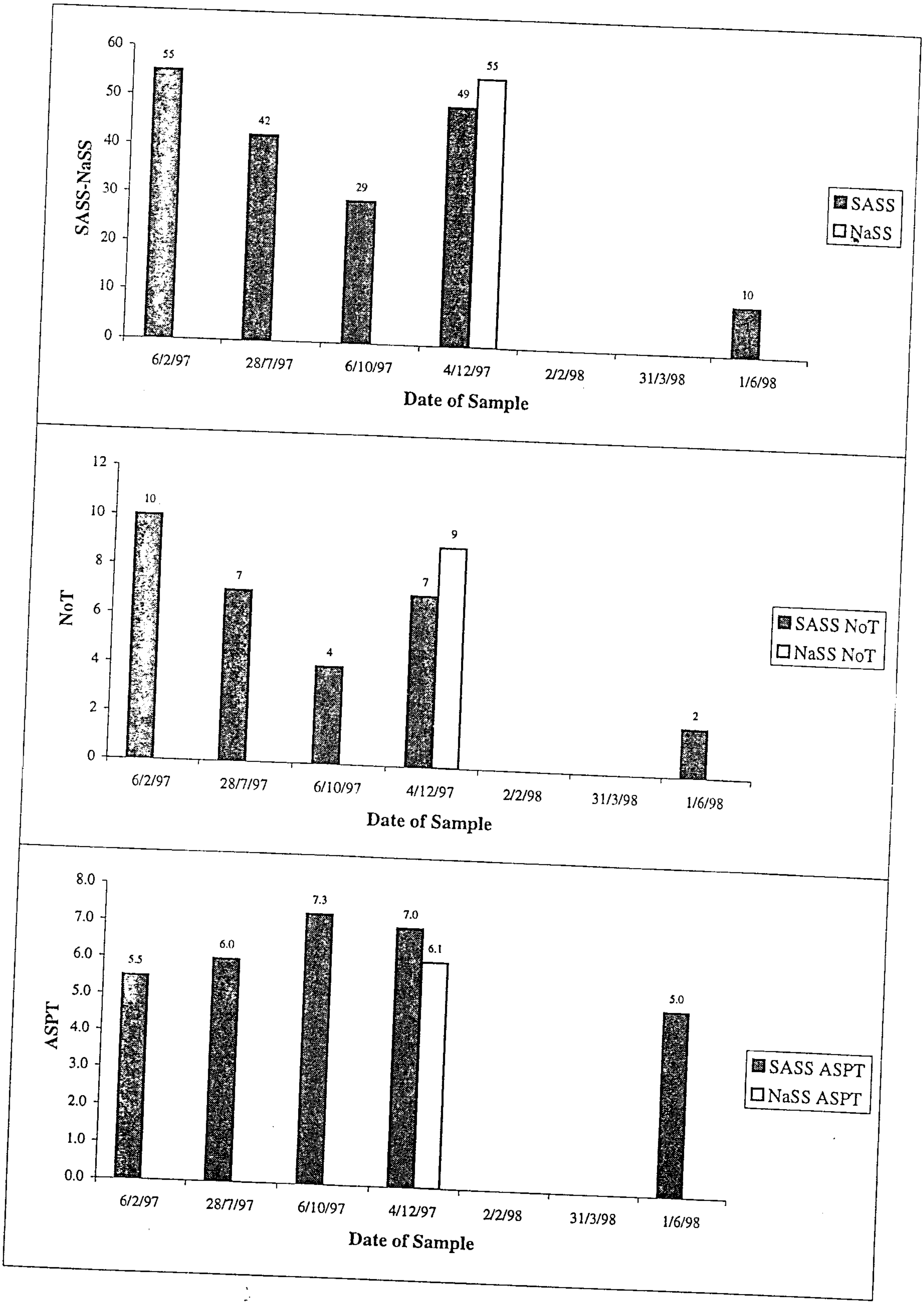
The list of taxa for the AV habitat at Cheye is shown in Table 2 in Appendix I. The scores from this habitat are shown in Table 6 and represented graphically in Figure 5.

Table 6 Water quality scores for Cheye – Aquatic vegetation habitat

Date	SASS Score	SASS NoT	SASS ASPT	NaSS Score	NaSS NoT	NaSS ASPT
2/6/97	55	10	5.5	-	-	-
28/7/97	42	7	6.0	-	-	-
6/10/97	29	4	7.3	-	-	-
4/12/97	55	7	7.0	55	9	6.4
2/2/98	-	-	-	-	-	-
31/3/98	-	-	-	-	-	-
1/6/98	10	2	5.0	-	-	-

In the AV habitat the SASS score dropped from June to October as did the NoT, whereas the ASPT rose during the same period. This showed that although the number of animals found dropped during this time, there were a smaller number of higher scoring taxa left in the river. This was most likely due to the fact that as the water level dropped the AV habitat became less and less inundated and some individuals would have moved away, been left stranded, disturbed by livestock or people or eaten by fish. The few individuals left were high scoring taxa showing that although there was a good deal of physical disturbance, the water quality and thus chemistry of the river remained good. The increase in NoT and SASS in December was probably related to the rising water level flooding this habitat and the ASPT dropped slightly due to an influx of individuals that included some lower scoring taxa.

Figure 5 Graphs showing scores from the AV habitat at Cheye



No samples were taken from this habitat during the flood and the one taken in June 1998 was the first after a large flood and the aquatic vegetation had obviously not recolonised properly since then. In the majority of cases the ASPT score was ≥ 6.0 whereas the SASS/NaSS scores were <100, indicating good water quality but reduced habitat diversity, as would be expected for samples from a single habitat type. ASPT scores of < 6.0 were only recorded in June 1997 and 1998 just after the floods.

The list of taxa for the MV habitat at Cheye is shown in Table 3 in Appendix I. The scores from this habitat are shown in Table 7 and represented graphically in Figure 6.

Table 7 Water quality scores for Cheye – Marginal vegetation habitat

Date	SASS Score	SASS NoT	SASS ASPT	NaSS Score	NaSS NoT	NaSS ASPT
2/6/97	-	-	-	-	-	-
28/7/97	-	-	-	-	-	-
6/10/97	-	-	-	-	-	-
4/12/97	-	-	-	-	-	-
2/2/98	40	8	5.0	-	-	-
31/3/98	78	13	6.0	81	14	5.8
1/6/98	92	14	6.6	-	-	-

The MV habitat was only sampled in the last three months of the study, when the river was in full flood and immediately afterwards. SASS/NaSS, NoT and ASPT scores all increased from February through to June – probably related to colonisation of the MV habitat once inundated. By June, the ASPT was well above 6.0 and the SASS score close to 100 indicating natural water quality and good habitat diversity.

The list of taxa for the SOOC habitat at Cheye is shown in Table 4 in Appendix I. The scores from this habitat are shown in Table 8 and represented graphically in Figure 7.

Table 8 Water Quality scores for Cheye – Stones out of current

Date	SASS Score	SASS NoT	SASS ASPT	NaSS Score	NaSS NoT	NaSS ASPT
2/6/97	-	-	-	-	-	-
28/7/97	50	7	7.1	-	-	-
6/10/97	44	6	7.3	47	7	6.7
4/12/97	30	6	5.0	-	-	-
2/2/98	-	-	-	-	-	-
31/3/98	-	-	-	-	-	-
1/6/98	-	-	-	-	-	-

Samples taken from the SOOC habitat were from an area of the river heavily utilised by people and livestock. The substratum was not available in June 1997 or during 1998 due to the depth of water at the site. SASS, NoT and ASPT scores generally fell during the three months in which samples were taken, which was most likely related to physical rather than chemical disturbance. ASPT scores were generally ≥ 6.0, indicating clean water but SASS/NaSS were scores always <100, as would be expected from a single habitat type.

Figure 6 Graphs sowing scores from the MV habitat at Cheye

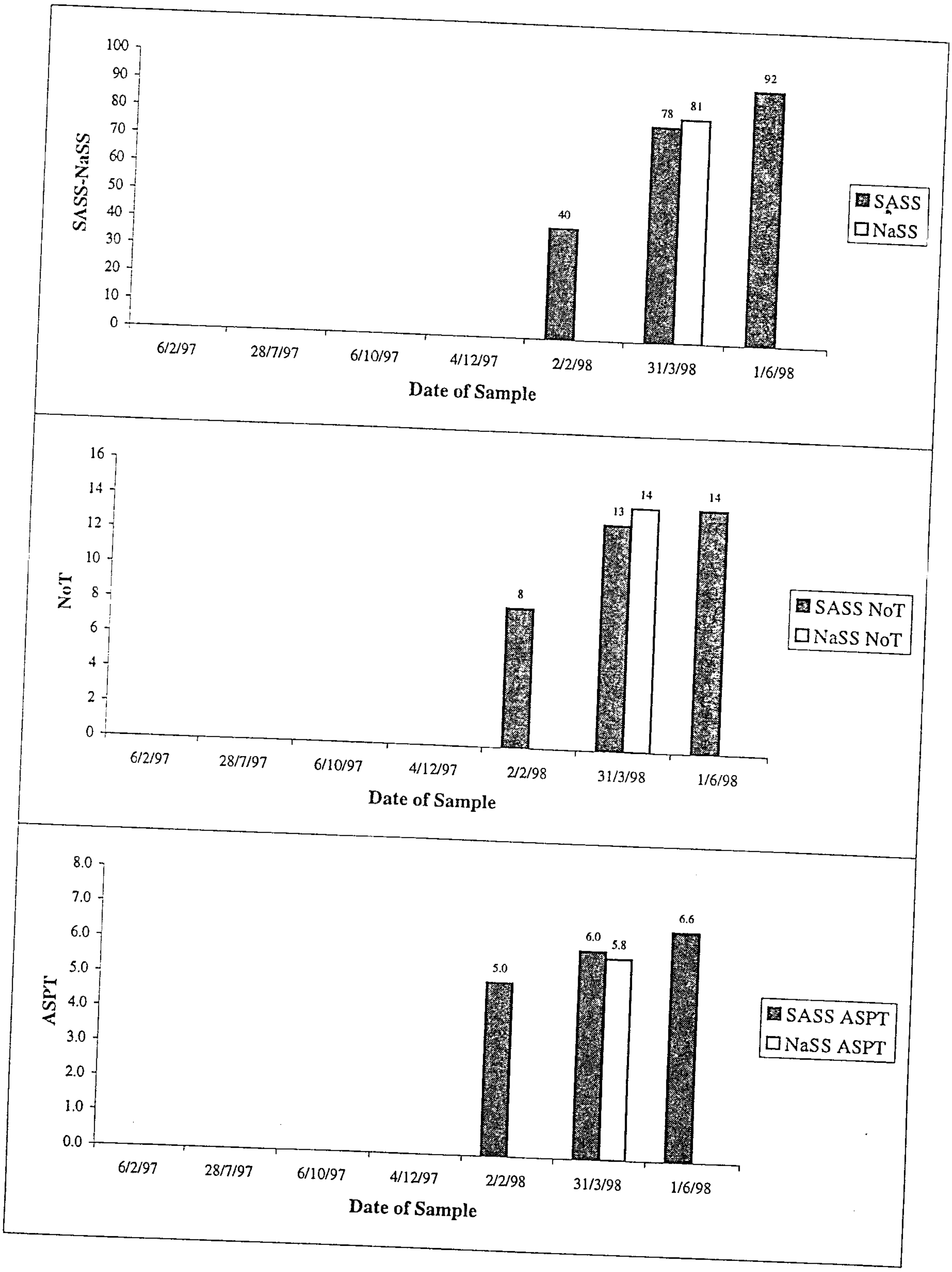


Figure 7 Graphs sowing scores from the SOOC habitat at Cheye

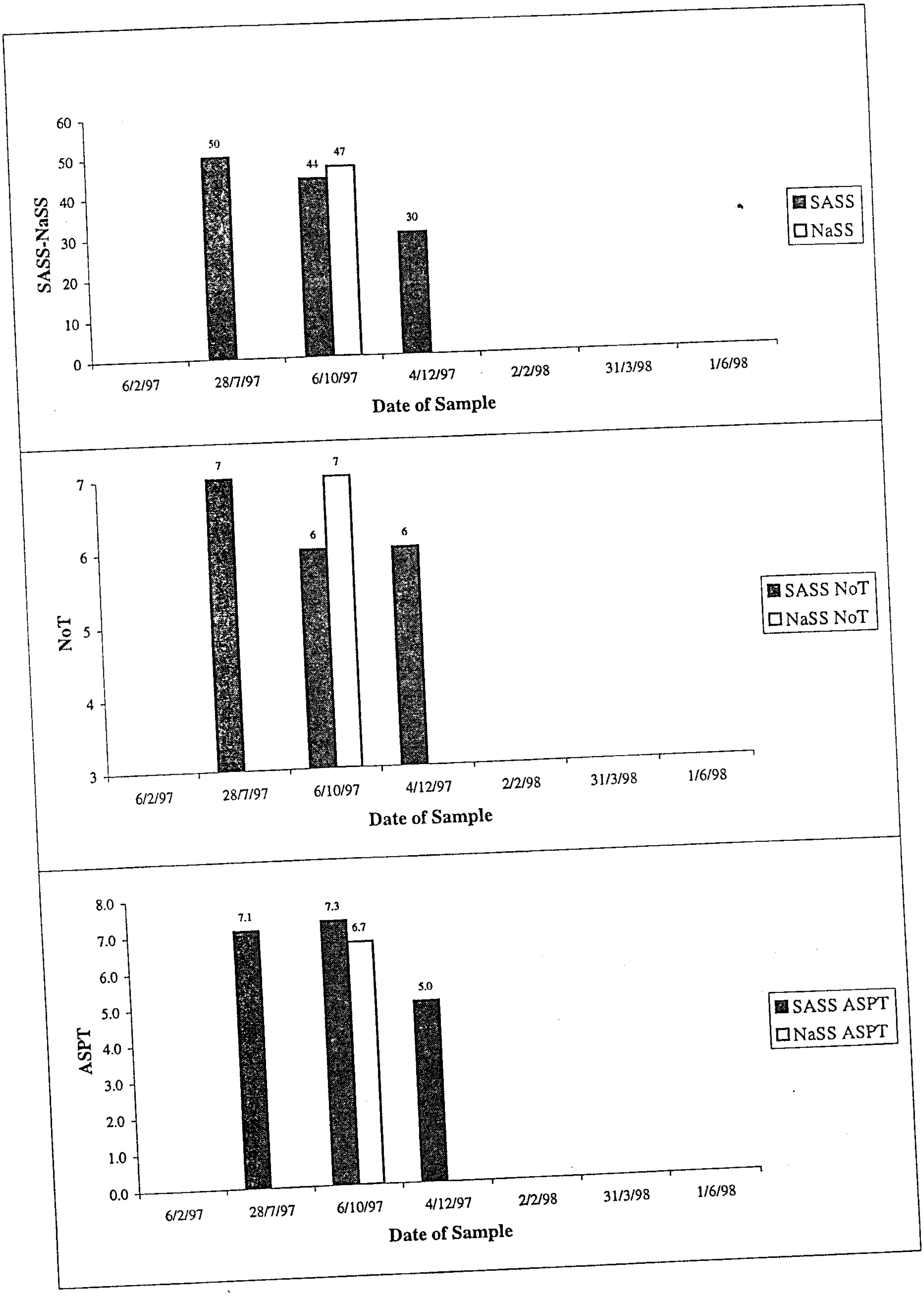
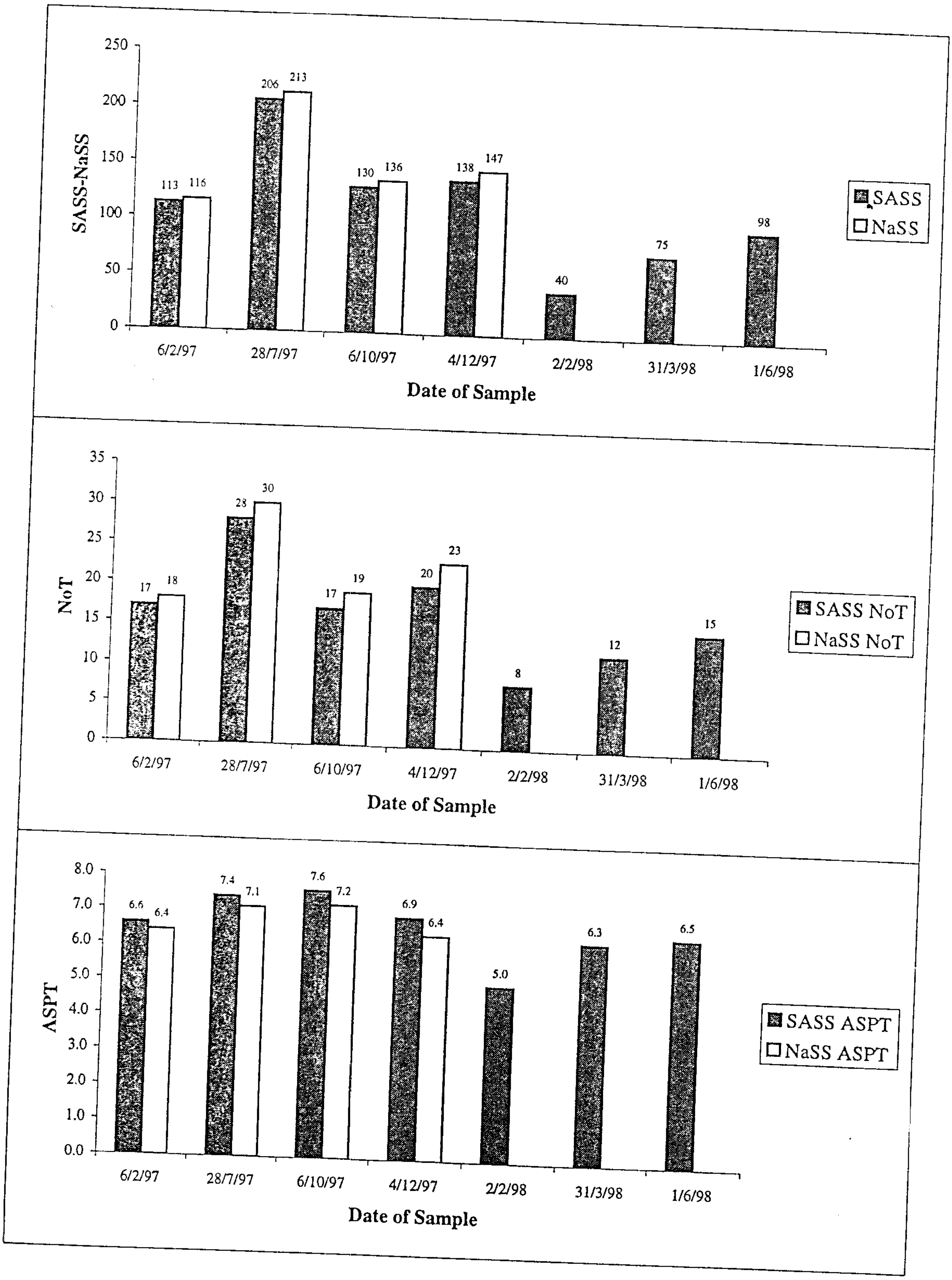


Figure 8 Graphs showing scores for all habitats combined at Cheye



The list of taxa for all habitats combined at Cheye is shown in Table 5 in Appendix I. The scores are shown in Table 9 and represented graphically in Figure 8.

Table 9 Water Quality scores for Cheye – All habitats combined

Date	SASS Score	SASS NoT	SASS ASPT	NaSS Score	NaSS NoT	NaSS ASPT
2/6/97	113	17	6.6	116	18	6.4
28/7/97	206	28	7.4	213	30	7.1
6/10/97	130	17	7.6	136	19	7.2
4/12/97	138	20	6.9	147	23	6.4
2/2/98	40	8	5.0	-	-	-
31/3/98	78	13	6.0	81	14	5.8
1/6/98	98	15	6.5	-	-	-

Once all habitats were combined the picture for this site became very clear. ASPT scores were generally all above 6.0 and SASS/NaSS scores above 100, indicating natural water quality conditions, i.e. no pollution, and a diverse habitat structure in the river at this point. Seasonal fluctuations in the invertebrate fauna appeared to be most strongly related to the flood cycle in the river with the highest scores occurring during low water. They were reduced at the height of the flood and then improved again afterwards. The greatest SASS/NaSS and NoT scores were found towards the end of the winter when the water level was low and before the water had warmed up. The highest ASPT score occurred somewhat later than this in October showing the largest number of high scoring taxa were found at this time.

3.3.1.2 Popa Falls

Three different habitat types were sampled at Popa Falls: Stones In Current (SIC), Sand and Marginal Vegetation (MV). MV was available the whole year round, although the quality varied from month to month as the ease of access to the river altered due to the volume of flow. For example, the MV sampled in February, June and July '97 consisted only of a few shoots of reeds (*Phragmites mauritianus*) at the edge of the main channel. In October and December '97 consisted of overhanging shoots, and some of the root bowl, of hippo grass (*Vossia cuspidata*) on a small island in the main channel. The latter type provided a much more diverse habitat than the former. SIC was available, in pretty much the same form for the majority of the year except March '98 when the river was too deep to enter. The sand habitat was available for half the months, dependent on the presence of enough sand and on the depth of the water over it.

The list of taxa for the SIC habitat at Popa Falls is shown in Table 1 in Appendix II. The scores from this habitat are shown in Table 10 and represented graphically in Figure 9.

Figure 9 Graphs showing scores for the SIC habitat at Popa

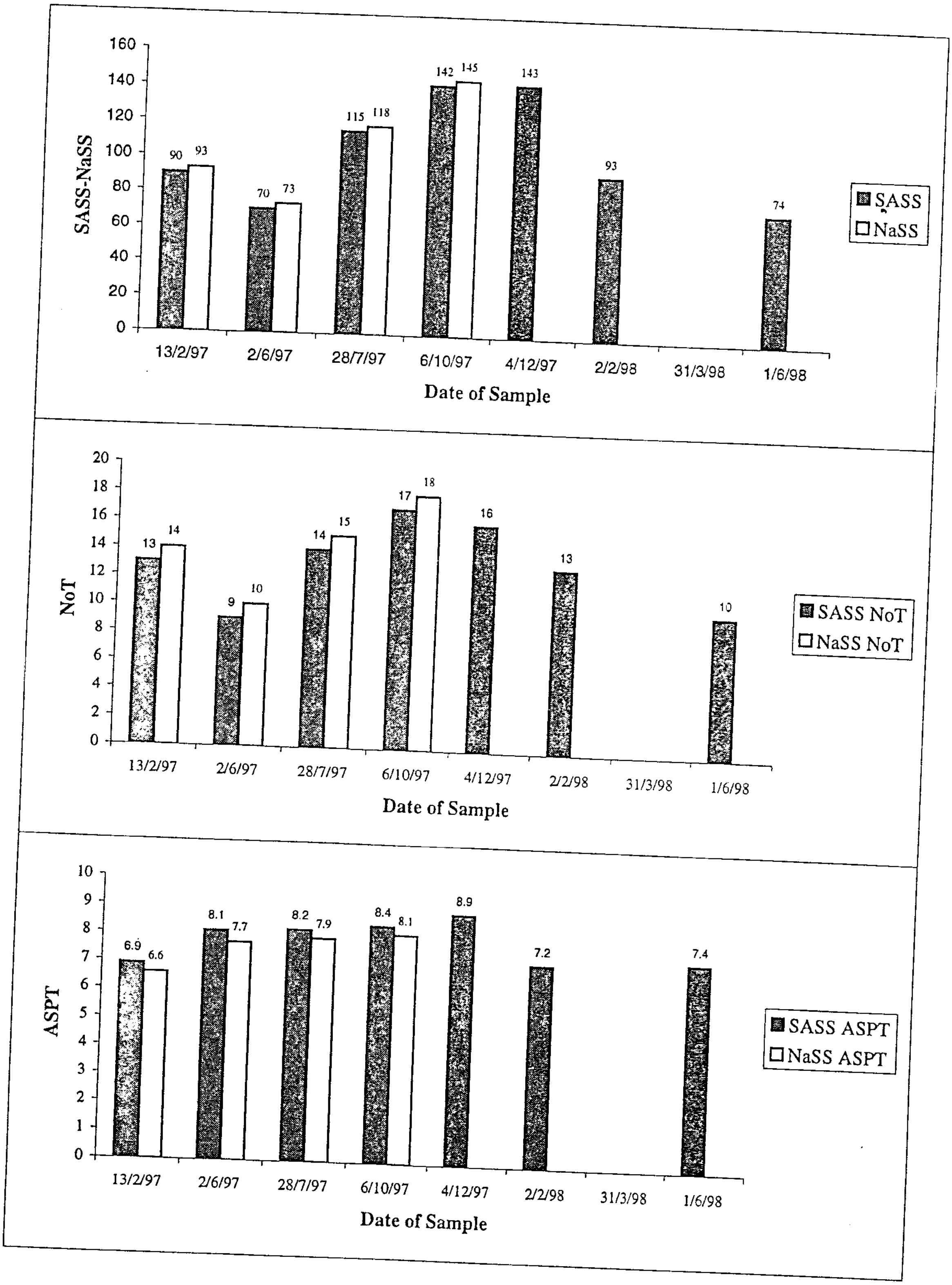


Table 10 **Water Quality scores for Popa Falls – Stones in Current habitat**

Date	SASS Score	SASS NoT	SASS ASPT	NaSS Score	NaSS NoT	NaSS ASPT
13/2/97	90	13	6.9	93	14	6.6
2/6/97	70	9	7.7	73	10	7.3
28/7/97	115	14	8.2	118	15	7.9
6/10/97	142	17	8.4	145	18	8.1
4/12/97	143	16	8.9	-	-	-
2/2/98	93	13	7.2	-	-	-
31/3/98	-			-	-	-
1/6/98	74	10	7.4	-	-	-

In the SIC habitat the SASS/NaSS and NoT scores started to rise in June and reached a peak in October, ASPT scores followed a very similar trend but peaked slightly later in December '97. The drop observed between February and June 1997 was thought to be related to the flood that occurred between theses two times and a similar trend was seen in the data collected in 1998. Scores for this habitat followed a very similar trend for the scores from the SIC habitat at Cheye some *circa* 150km upstream. For all the samples taken in this habitat, ASPT was >6.0 and SASS/NaSS >100 indicating excellent water quality and the importance of the SIC habitat.

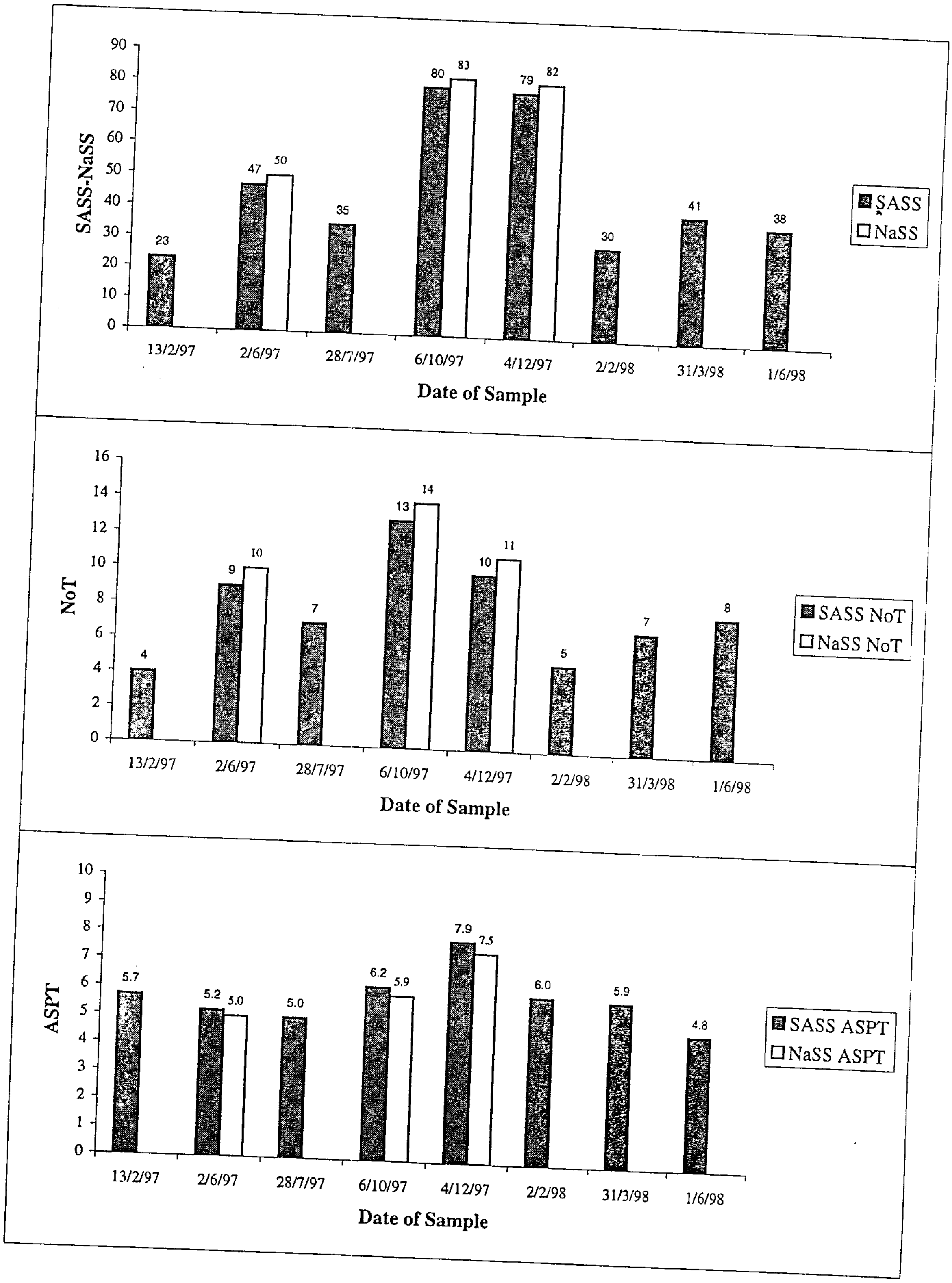
The list of taxa for the MV habitat at Popa Falls is shown in Table 2 in Appendix II. The scores from this habitat are shown in Table 11 and represented graphically in Figure 10.

Table 11 **Water Quality scores for Popa Falls – Marginal vegetation habitat**

Date	SASS Score	SASS NoT	SASS ASPT	NaSS Score	NaSS NoT	NaSS ASPT
13/2/97	23	4	5.7	-	-	-
2/6/97	47	9	5.2	50	10	5.0
28/7/97	35	7	5.0	-	-	-
6/10/97	80	13	6.2	83	14	5.9
4/12/97	79	10	7.9	82	11	7.5
2/2/98	30	5	6.0	-	-	-
31/3/98	41	7	5.9	-	-	-
1/6/98	38	8	4.8	-	-	-

The pattern of change in scores for the MV habitat was similar to that for SIC but somewhat more erratic. This variation was probably related to the differences in the type of MV sampled on separate sampling occasions. Unlike at Cheye, where the MV scores were highest during and just after the flood, the scores here were highest at the same time of year as the SIC habitat scores. This was thought to be related to the ability to access high quality MV habitat at that time of year when the river was experiencing low flows. When good quality MV was not available, scores dropped slightly from one occasion to the next, most likely to do with gradual drying of the habitat as the river level fell. Approximately half the ASPT scores were <6.0 and all the SASS/NaSS scores were <100. When the best MV habitat was sampled however the ASPT was >6.0 and the SASS/NaSS scores were between 50 – 100, indicating that the water quality was good but that the habitat was restricted, as would be expected from a single habitat sample.

Figure 10 Graphs showing scores for the MV habitat at Popa



The list of taxa for the Sand habitat at Popa Falls is shown in Table 3 in Appendix II. The scores from this habitat are shown in Table 12 and represented graphically in Figure 11.

Table 12 **Water Quality scores for Popa Falls – Sand habitat**

Date	SASS Score	SASS NoT	SASS ASPT	NaSS Score	NaSS NoT	NaSS ASPT
13/2/97	-	-	-	-	-	-
2/6/97	20	4	5.0	-	-	-
28/7/97	-	-	-	-	-	-
6/10/97	18	4	4.5	21	5	4.2
4/12/97	8	1	8.0	-	-	-
2/2/98	40	6	6.7	43	7	6.1
31/3/98	-	-	-	-	-	-
1/6/98	-	-	-	-	-	-

There was no consistent pattern visible in the scores obtained from the Sand habitat reflecting the mobile nature of this substratum and the problems that invertebrate taxa have with dealing with this. Sand is thus not a good habitat from which to try and determine water quality, unless it is the only substratum available at a site. Samples taken from this habitat should always be considered in conjunction with samples from other habitats at the same site wherever possible.

The list of taxa for all habitats combined at Popa Falls is shown in Table 4 in Appendix II. The scores from this habitat are shown in Table 13 and represented graphically in Figure 12.

Table 13 **Water Quality scores for Popa Falls, All habitats combined**

Date	SASS Score	SASS NoT	SASS ASPT	NaSS Score	NaSS NoT	NaSS ASPT
13/2/97	90	13	6.9	93	14	6.6
2/6/97	102	16	6.4	105	17	6.2
28/7/97	142	19	7.5	145	20	7.3
6/10/97	198	27	7.3	201	28	7.2
4/12/97	172	21	8.2	175	22	8.0
2/2/98	124	16	7.8	127	17	7.5
31/3/98	41	7	5.9	-	-	-
1/6/98	94	15	6.3	-	-	-

Combining all habitats gave a fairly clear picture of the changes over the year, particularly when considering the SASS/NaSS and the NoT scores. The score for both categories increased steadily from February to July and reached a peak in October '97. They then fell away again as the river rose and flooded between January and June '98. A similar pattern was observed in the ASPT scores although their rise to a maximum in December '97 was more erratic than those for SASS/NaSS and NoT. ASPT scores did however show the same pattern as for the other scores as the river rose and flooded, dropping to a low in March 1998 and then showing a rise in June '98. The combined scores showed that the water quality in the river was very good as the vast majority of SASS/NaSS scores were >100 and the ASPT scores > then 6.0. Fluctuations in the scores throughout the course of the study were thought to be due entirely to seasonal changes in the fauna and sampling practicalities dictated by the flood rather than to changes in water quality.

Figure 11 Graphs showing scores for the Sand habitat at Popa

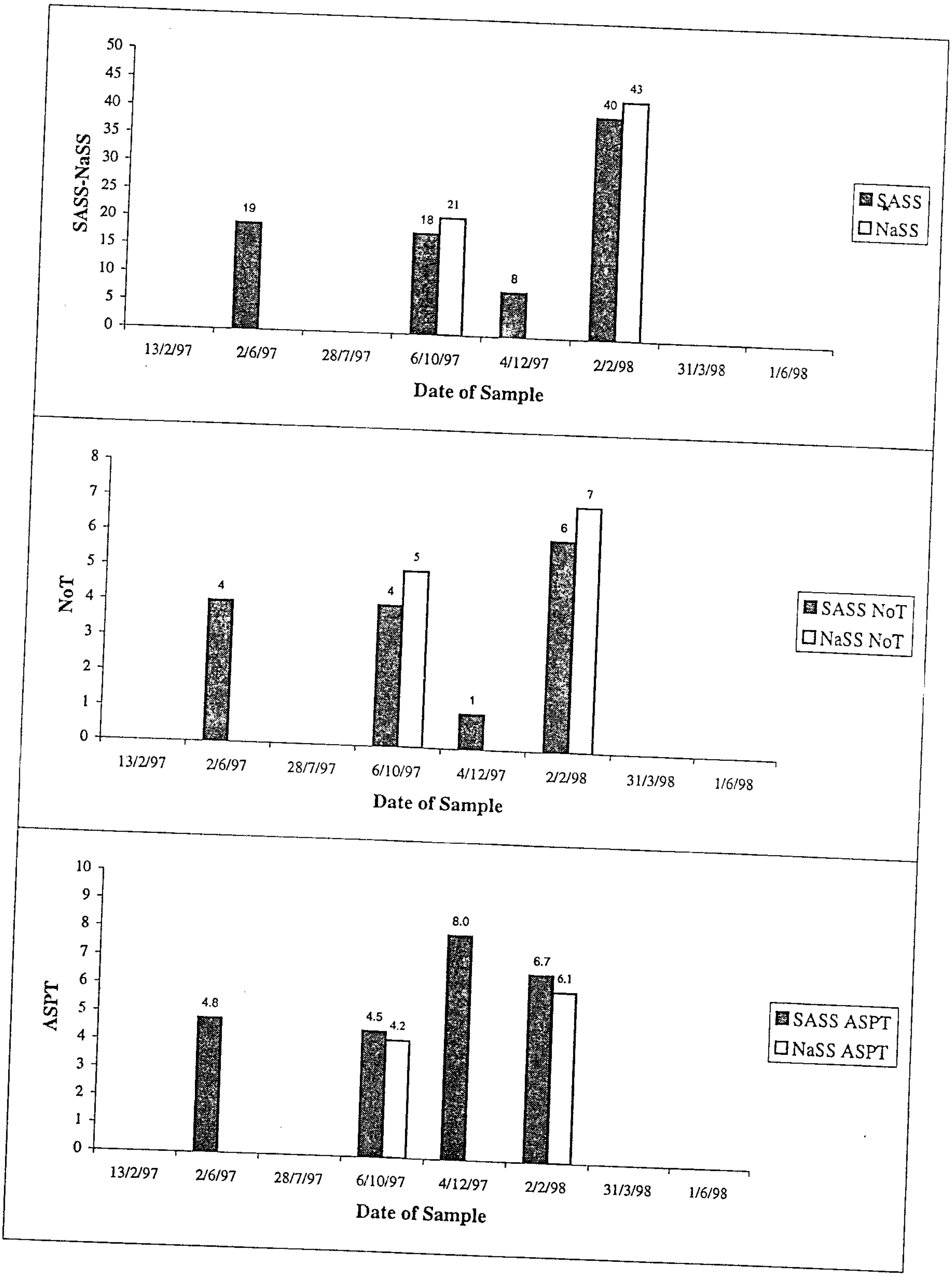
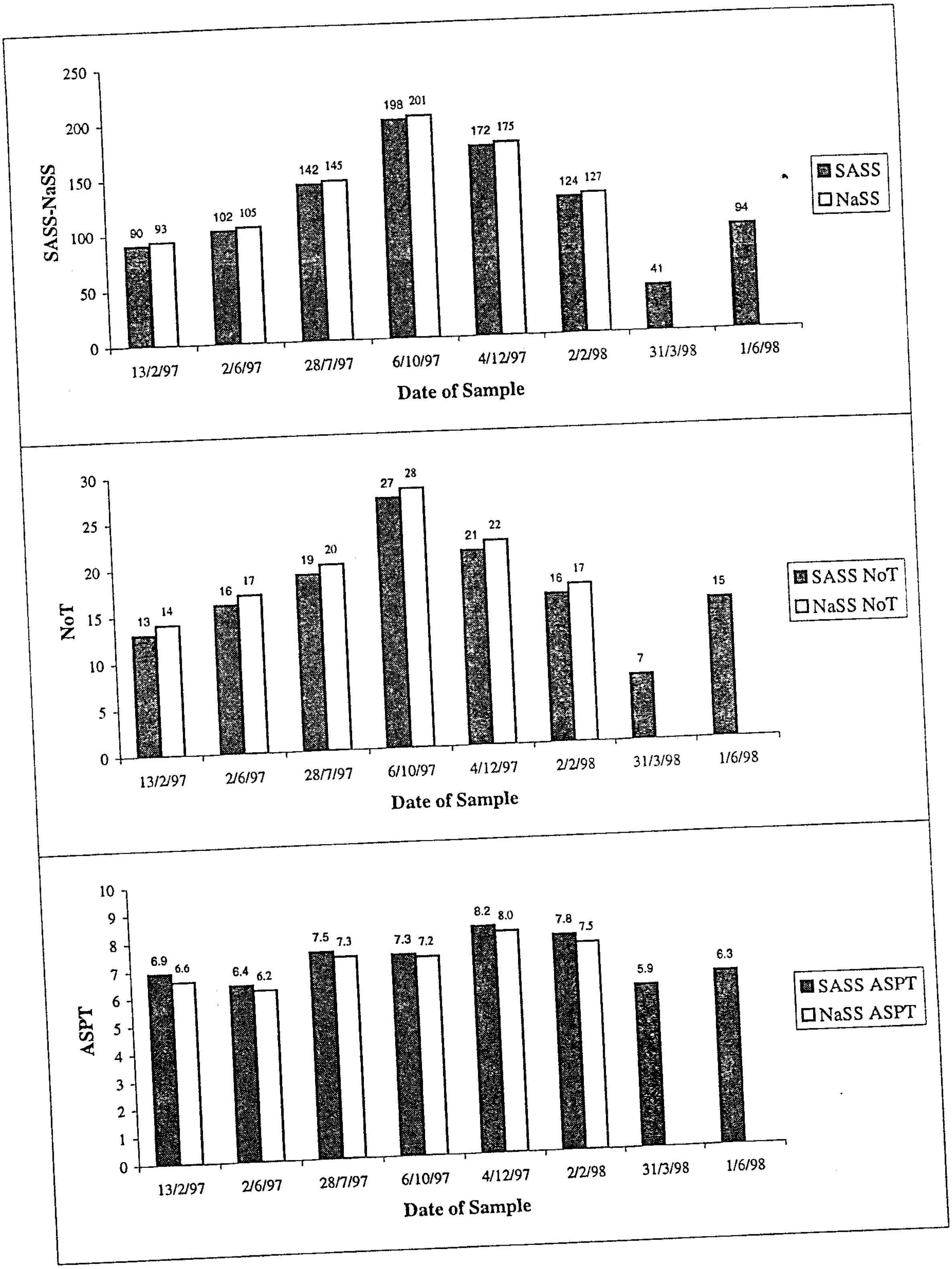


Figure 12 Graphs showing scores for all habitats combined at Popa



3.3.2 The Kwando River

3.3.2.1 Kongola Bridge

Three habitats were available throughout the study period at this site, namely SIC, AV (*Potamogeton thumbergii*) and MV (*Vossia cuspidata*). Unlike all the other sites sampled on the Zambezi, Okavango and Chobe rivers, the water level at this site varied very little (max. of *circa* 30cm). The high water also occurred much later in the year somewhere between the end of July and the end of August. Changes in the SASS/NaSS, Not and ASPT scores seemed to bear no relation to water level fluctuations.

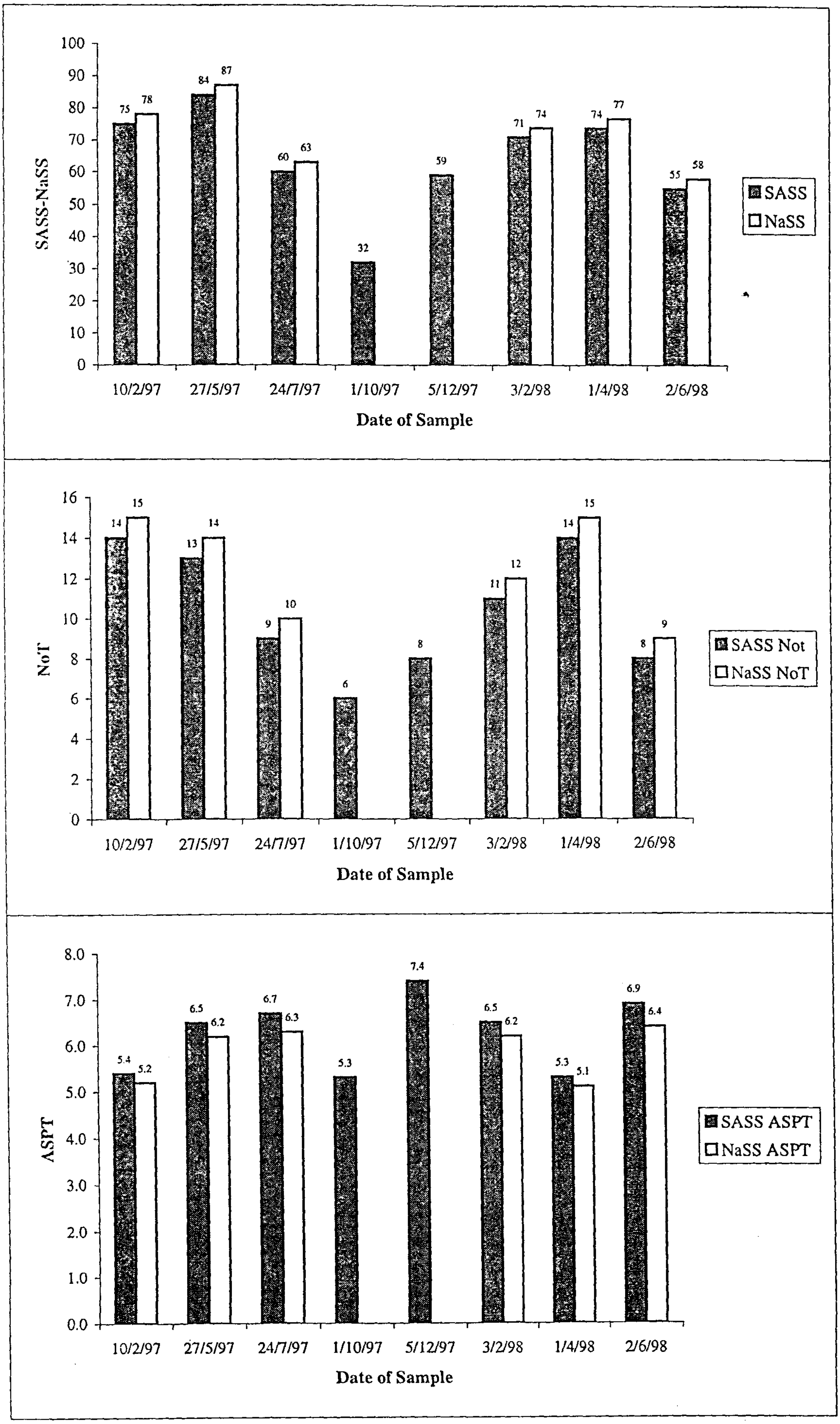
The list of taxa for the SIC habitat at Kongola is shown in Table 1 in Appendix III. The scores from this habitat are shown in Table 14 and represented graphically in Figure 13.

Table 14 **Water Quality scores for Kongola, Stones In Current habitat**

Date	SASS Score	SASS NoT	SASS ASPT	NaSS Score	NaSS NoT	NaSS ASPT
10/2/97	75	14	5.4	78	15	5.2
27/5/97	84	13	6.5	87	14	6.2
24/7/97	60	9	6.7	63	10	6.3
1/10/97	32	6	5.3	-	-	-
5/12/97	59	8	7.4	-	-	-
3/2/98	74	11	6.5	74	12	6.2
1/4/98	77	14	5.3	77	15	5.1
2/6/98	58	8	6.9	58	9	6.4

In the SIC habitat SASS/NaSS and NoT scores generally fell between February and July, reaching a low in October 1997. These scores then increased again until April before falling in June '98. Almost the exact opposite trend was seen in ASPT scores which rose as SASS/NaSS and NoT scores fell and vice versa. The changes in these scores were difficult to interpret as the clear relationship between water level fluctuations and/or water temperature (determined by season), seen at the other sites, was absent here. There may possibly have been some link between changes in the fauna and the onset of the rainy season as scores fell throughout the dry season and then rose again when the rains came. It is possible that run-off from heavy rain events was enough to provide an increase in nutrients despite no visible change in water level. This may have been enough to induce growth and breeding in many taxa, particularly in the generally nutrient poor Kwando system. SASS/NaSS and NoT scores thus rose as abundance and richness increased whereas ASPT scores fell due to the presence of a larger number of lower scoring taxa. It might also have been that taxa deliberately relocated to the SIC habitat during the rainy season for some reason, provision of a better food resource for example. Invertebrates may have only made this shift of habitats in the rainy season when the water was more turbid and they were less visible and consequently less likely to fall prey to fish and other predators. SASS/NaSS scores were generally between 50-100 and ASPT scores usually >6.0 suggesting that water quality was reasonably good but that habitat was a limiting factor. Reduced SASS/NaSS were not found for any other SIC habitat sampled on the other rivers and may have been related to the lack of stone based riffles and rapids in this river.

Figure 13 Graphs showing scores for the SIC habitat at Kongola



The majority of the riverbed was composed of sand and thus the taxa commonly found inhabiting stony rapids were sparse, indeed the rapid sampled at Kongola was probably only formed by construction of the bridge. The Kwando area has also been subjected to intensive programmes to control mosquitoes, tsetse fly and *Bulinus* spp. snails for malaria, sleeping sickness and bilharzia respectively. It is possible that the pesticides used to control these disease vectors have had an adverse impact on the entire riverine invertebrate fauna and this has caused the lower scores observed at this site. The Kwando has also been subject to the low flows and lack of substantial flooding for approximately 10 years now and is thought by some observers to be drying up. This continual reduction in the volume of water, and particularly in the natural flood cycle of the river, is also bound to have had adverse affects on the invertebrate fauna and it may well be this effect that has been observed here.

The list of taxa for the AV habitat at Kongola is shown in Table 2 in Appendix III. The scores from this habitat are shown in Table 15 and represented graphically in Figure 14.

Table 15 **Water Quality scores for Kongola, Aquatic Vegetation habitat**

Date	SASS Score	SASS NoT	SASS ASPT	NaSS Score	NaSS NoT	NaSS ASPT
10/2/97	-	-	-	-	-	-
27/5/97	65	10	6.5	-	-	-
24/7/97	32	7	4.6	35	8	4.8
1/10/97	46	9	5.1	49	10	4.9
5/12/97	38	7	5.4	-	-	-
3/2/98	47	8	5.9	-	-	-
1/4/98	50	9	5.6	-	-	-
2/6/98	49	11	4.5	52	12	4.3

The pattern of change in SASS/NaSS and NoT scores for the AV habitat was again difficult to interpret. After an initial high, SASS/NaSS and NoT scores then fell back but rose again until October 1997. They then fell again but from there rose steadily until the end of the study period in June 1998. The change in ASPT scores was more consistent. They also started from an initial high and then fell back immediately on the second sampling occasion in July 1997. From there, ASPT rose gradually through until February 1998 and then fell away again. These changes appeared to be a combination of the patterns of change observed for SIC and MV. This was hardly surprising considering that the AV habitat comprised aspects of both the SIC and MV habitats, in that it consisted largely of the submerged and floating leaves of *Potamogeton thumbergii* and that it was growing in a stony substratum in fairly fast flowing water. The AV habitat here was thus perhaps providing both the benefits of the suggested shelter provided by the MV habitat and the feeding opportunities of the SIC. SASS/NaSS scores were generally <50 and ASPT <6.0, again punctuating the potential problems outlined from the other habitat types.

The list of taxa for the MV habitat at Kongola is shown in Table 3 in Appendix III. The scores from this habitat are shown in Table 16 and represented graphically in Figure 15.

Figure 14 **Graphs showing scores for the AV habitat at Kongola**

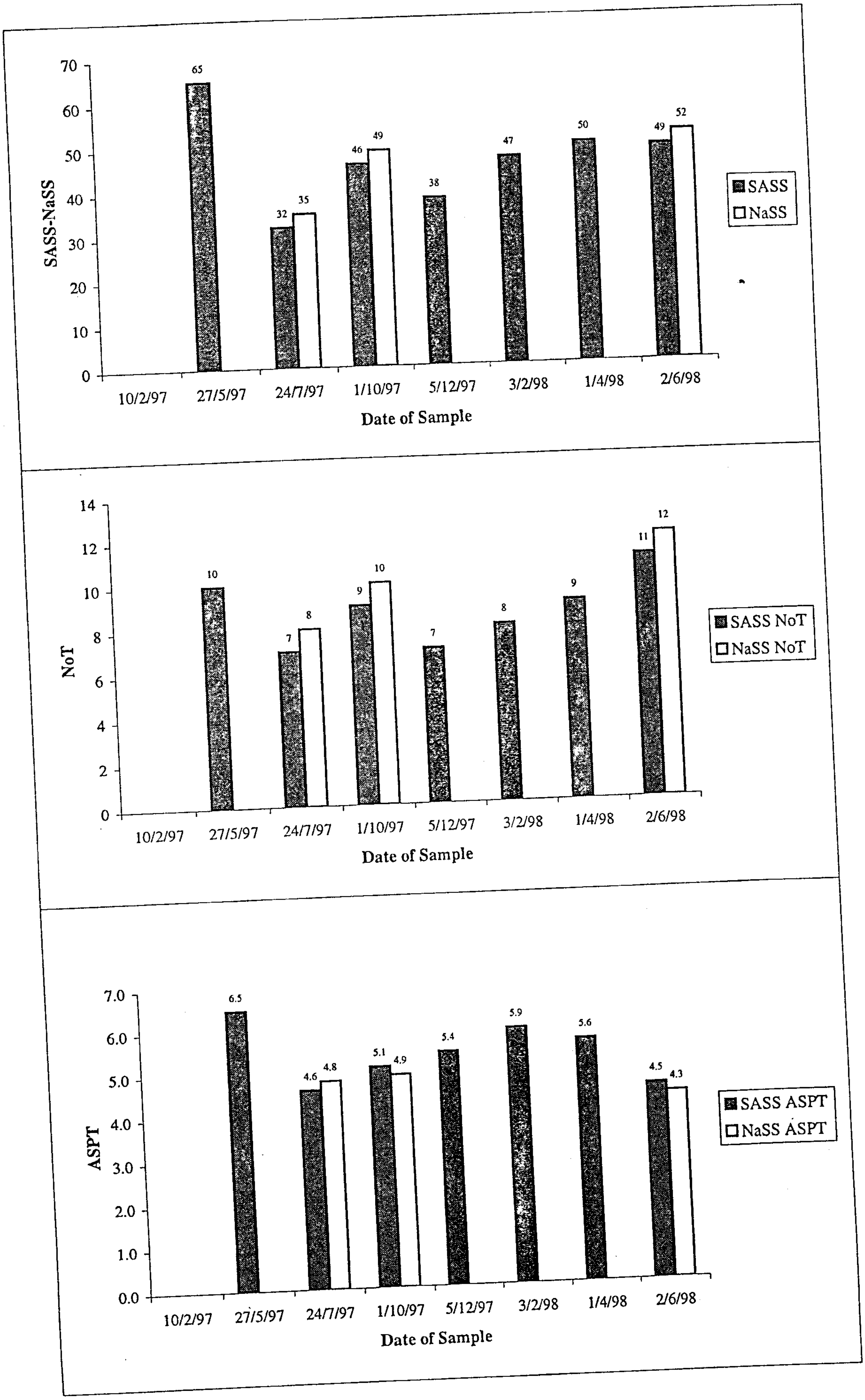


Figure 15 Graphs showing scores for the MV habitat at Kongola

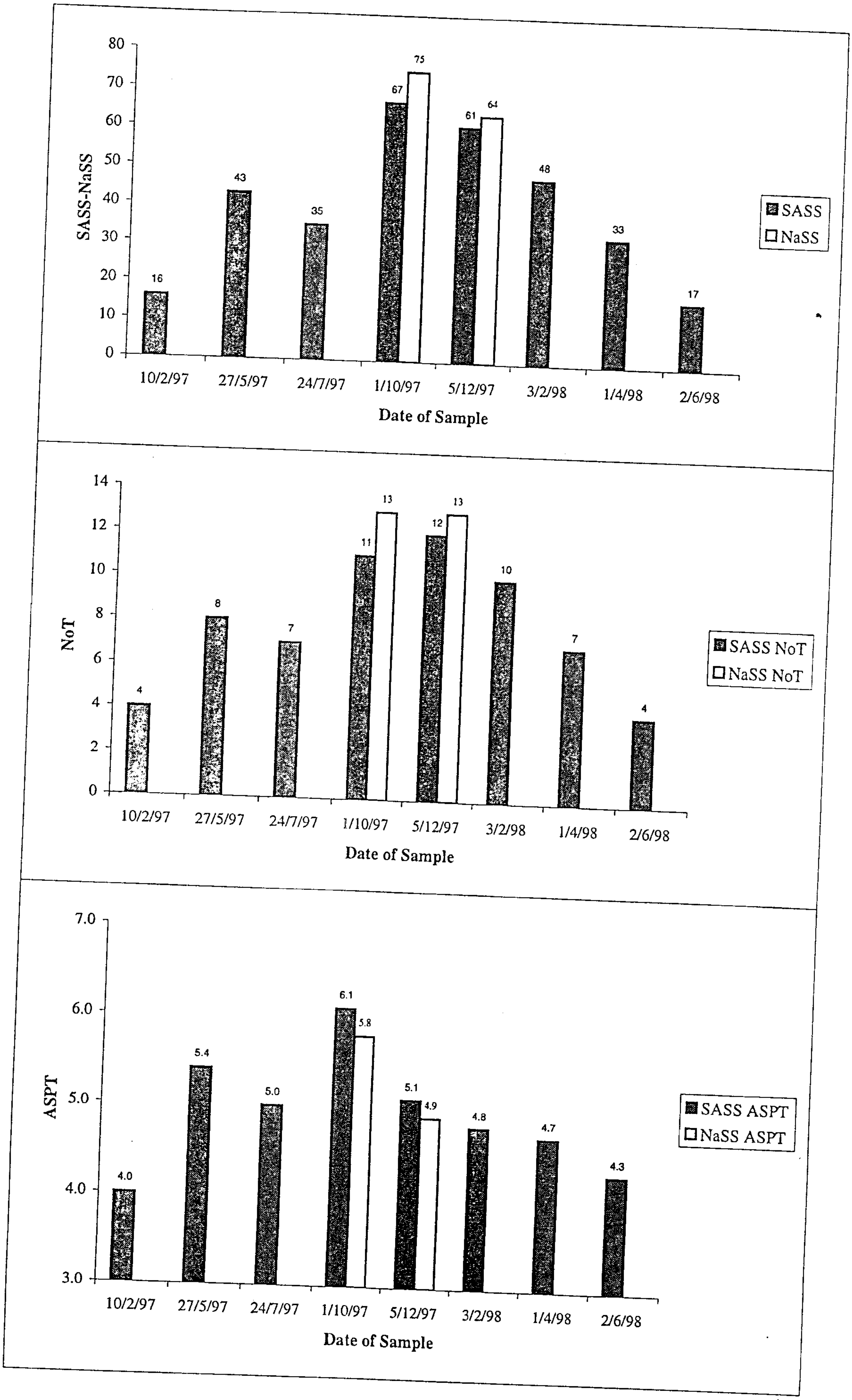


Table 16 **Water Quality scores for Kongola, Marginal Vegetation habitat**

Date	SASS Score	SASS NoT	SASS ASPT	NaSS Score	NaSS NoT	NaSS ASPT
10/2/97	16	4	4.0	-	-	-
27/5/97	43	8	5.4	-	-	-
24/7/97	35	7	5.0	-	-	-
1/10/97	67	11	6.1	75	13	5.8
5/12/97	61	12	5.1	64	13	4.9
3/2/98	48	10	4.8	-	-	-
1/4/98	33	7	4.7	-	-	-
2/6/98	17	4	4.3	-	-	-

SASS/NaSS, NoT and ASPT scores all showed the same trend in the MV habitat, which was opposite to that observed for SASS/NaSS and NoT scores in the SIC habitat. Scores rose from February through until July, peaked in October 1997 and then fell away again until the end of the study period. These changes were also difficult to interpret as again there was no clear link between water level fluctuations and/or water temperature seen at the other sites. As with the SIC habitat, timing of the observed changes coincided with changes in rainfall. Scores rose throughout the dry season and then fell again when the rains came. Unlike with the SIC habitat though the reason why the scores should fall with the onset of the rains was difficult to establish. If the river level had risen significantly it might have been attributed to "drowning" of the habitat, but that was not the case here. It would appear that, for some as yet undetermined reason, breeding took place in the MV habitat as the dry season proceeded or that perhaps taxa where relocating here during the dry season to avoid predation when the water was clearer. Once the rains came, however, breeding ceased or individuals and taxa moved away from MV onto other substrata. SASS/NaSS scores were generally between 50-100 and ASPT scores <6.0 in the majority of samples. Even though scores produced from a single habitat type are bound to be on the low side, these were some of the lowest scores recorded for a MV habitat in the study, reiterating the potential problems outlined above.

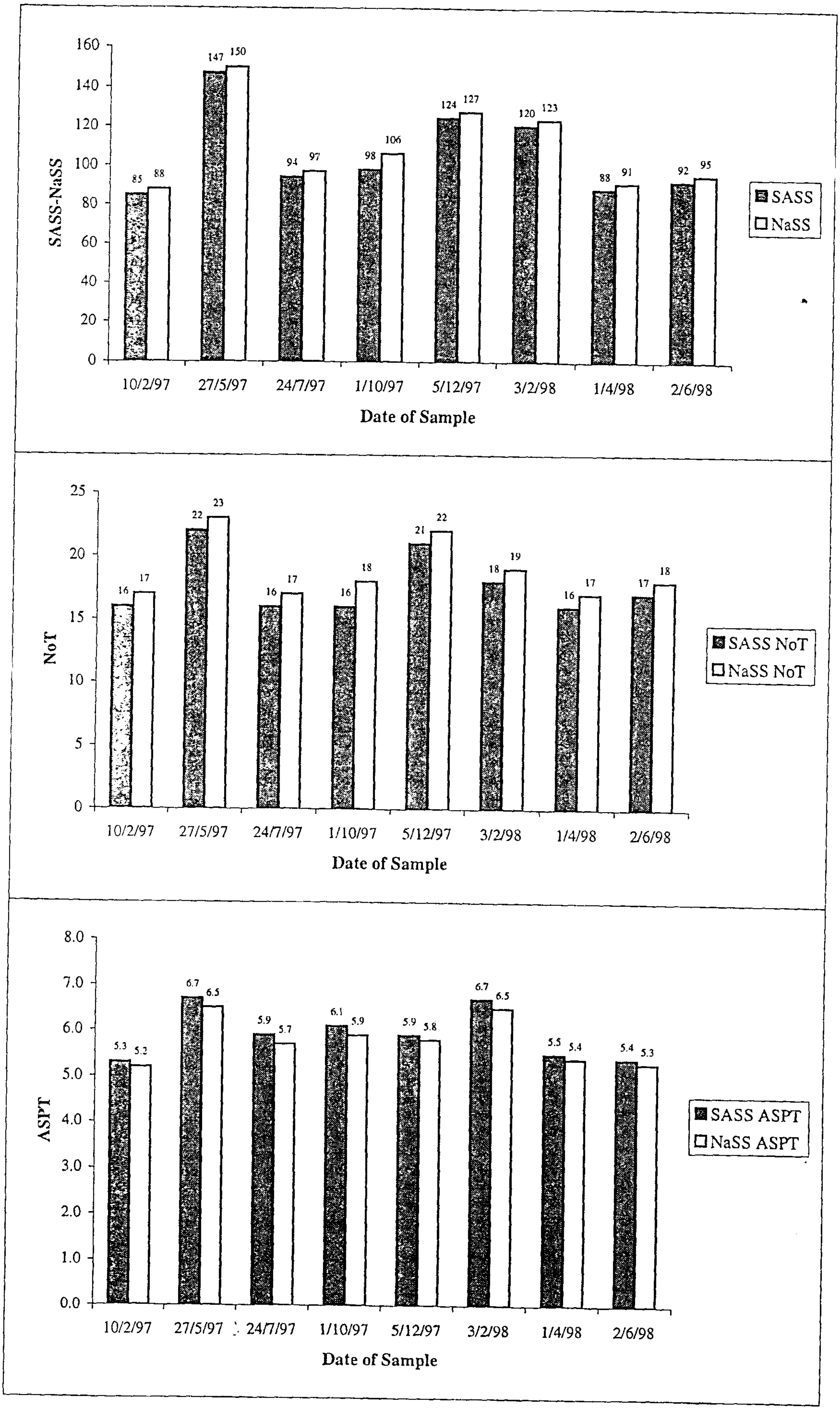
The list of taxa for all habitats at Kongola is shown in Table 4 in Appendix III. The scores from this habitat are shown in Table 17 and represented graphically in Figure 16.

Table 17 **Water Quality scores for Kongola, All habitats combined**

Date	SASS Score	SASS NoT	SASS ASPT	NaSS Score	NaSS NoT	NaSS ASPT
10/2/97	85	16	5.3	88	17	5.2
27/5/97	147	22	6.7	150	23	6.5
24/7/97	94	16	5.9	97	17	5.7
1/10/97	98	16	6.1	106	18	5.9
5/12/97	124	21	5.9	127	22	5.8
3/2/98	120	18	6.7	123	19	6.5
1/4/98	88	16	5.5	91	17	5.4
2/6/98	92	17	5.4	95	18	5.3

SASS/NaSS and NoT scores gradually increased from February - December 1997 (except in May) and then fell away again. ASPT scores showed a very similar trend but peaked later in February 1998. This pattern was difficult to interpret and, compared to many of the other sample sites, scores varied very little during the course of the year, probably due to lack of

Figure 16 Graphs showing scores for all habitats combined at Kongola



flooding in this system. Even the combined habitat SASS/NaSS were <100 on five occasions and ASPT scores were only >6.0 twice throughout the whole study period.

3.3.2 2 Lyadura

Two main habitats were sampled at this site, namely MV and AV. Silt from the bed of the river was also sampled on two occasions but further sampling was made difficult by the presence of crocodiles and the deep, turbid nature of the river at this point. Changes in all scores for all habitats appeared to have no pattern to them. It was likely that in the absence of any single driving factor, such as water level change, scores were entirely dependent on local conditions in the habitat sampled at the time of sampling.

ASPT scores from "all habitats combined" showed very little change from month to month despite the large fluctuations in SASS/NaSS and NoT scores. This indicated that although there was considerable variation in the number and type of taxa, it's overall response to water quality, season etc. remained fairly static. The majority of SASS/NaSS scores were between 50 – 100 with only three >100 and ASPT scores were mostly between 5.0 and 6.0. These results indicate that there has possibly been some water quality deterioration in the river at this site. Some of the explanations given for reduced scores at Kongola may also be pertinent here.

The lists of taxa for MV, AV, silt and all habitats combined at Lyadura are shown in Tables 1-4 respectively in Appendix IV. The scores from these habitats are shown in Table 18, 19, 20 & 21 and represented graphically in Figures 17, 18, 19 & 20 respectively.

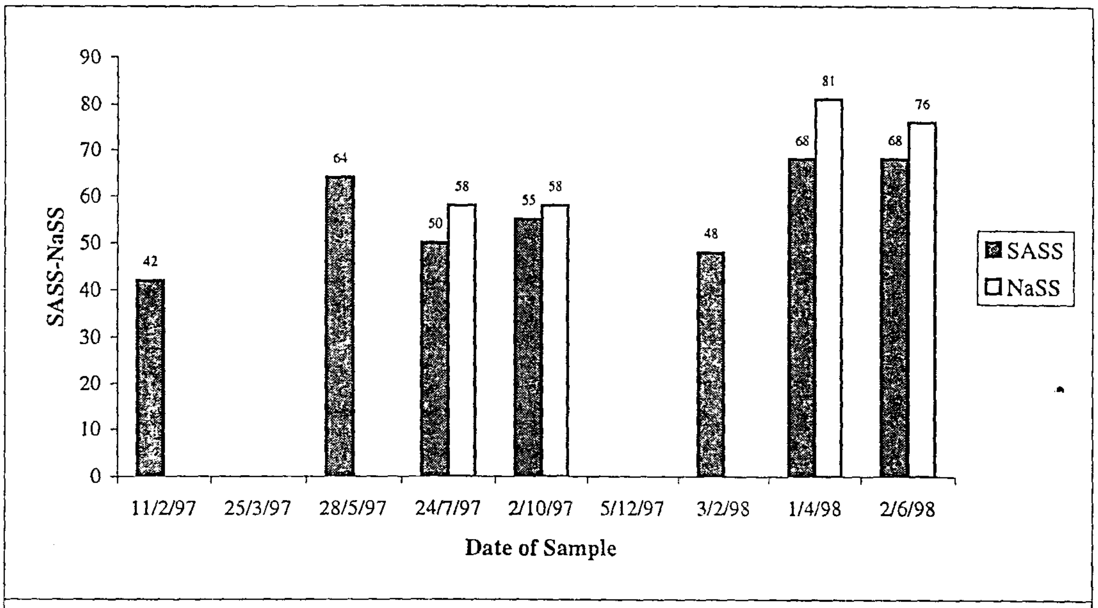
Table 18 **Water Quality scores for Lyadura, Marginal Vegetation habitat**

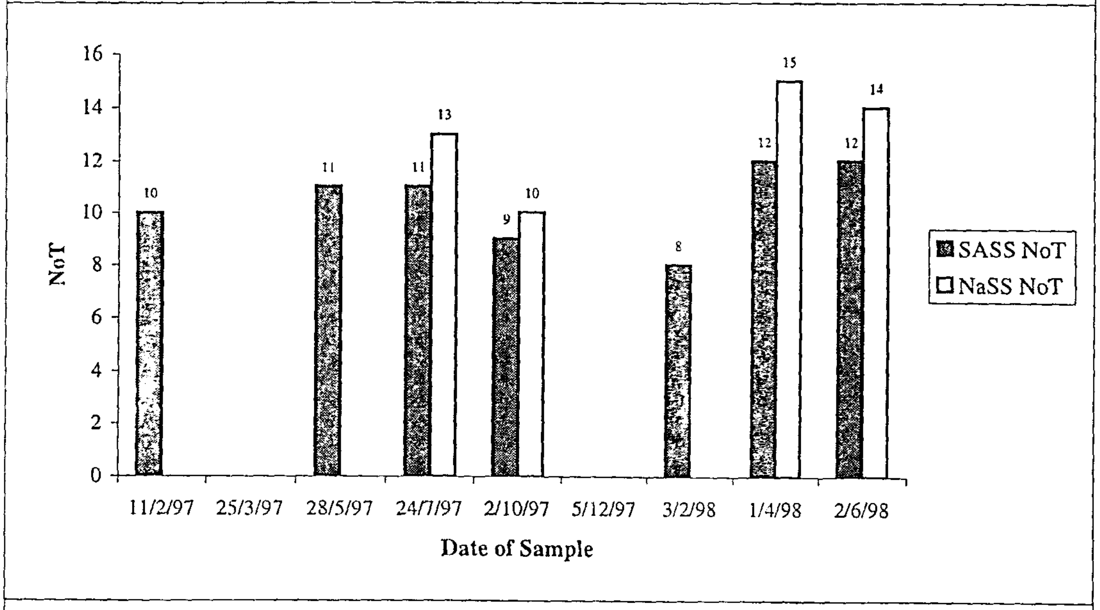
Date	SASS Score	SASS NoT	SASS ASPT	NaSS Score	NaSS NoT	NaSS ASPT
11/2/97	42	10	4.2	-	-	-
25/3/97	-	-	-	-	-	-
28/5/97	64	11	5.8	-	-	-
24/7/97	50	11	4.5	58	13	4.5
2/10/97	55	9	6.1	58	10	5.8
5/12/97	-	-	-	-	-	-
3/2/98	48	8	6.0	-	-	-
1/4/98	68	12	5.7	81	15	5.4
2/6/98	68	12	5.6	76	14	5.4

Table 19 **Water Quality scores for Lyadura, Aquatic Vegetation habitat**

Date	SASS Score	SASS NoT	SASS ASPT	NaSS Score	NaSS NoT	NaSS ASPT
11/2/97	61	13	4.7	64	14	4.6
25/3/97	98	18	5.4	106	20	5.3
28/5/97	24	5	4.8	-	-	-
24/7/97	74	12	6.2	79	13	6.1
2/10/97	29	8	3.6	32	9	3.6
5/12/97	86	15	5.7	89	16	5.6
3/2/98	41	9	4.6	44	10	4.4
1/4/98	84	16	5.3	92	18	51
2/6/98	65	10	6.5	-	-	-

Figure 17 Graphs showing scores for the MV habitat at Lyadura





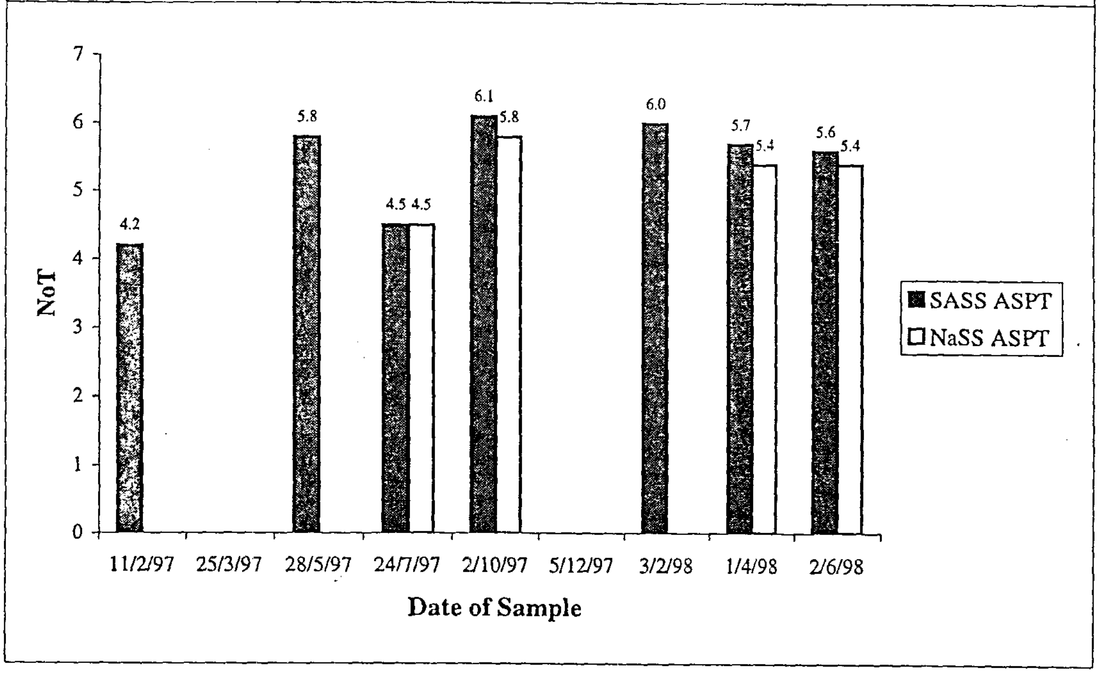


Figure 18 Graphs showing scores for the AV habitat at Lyadura

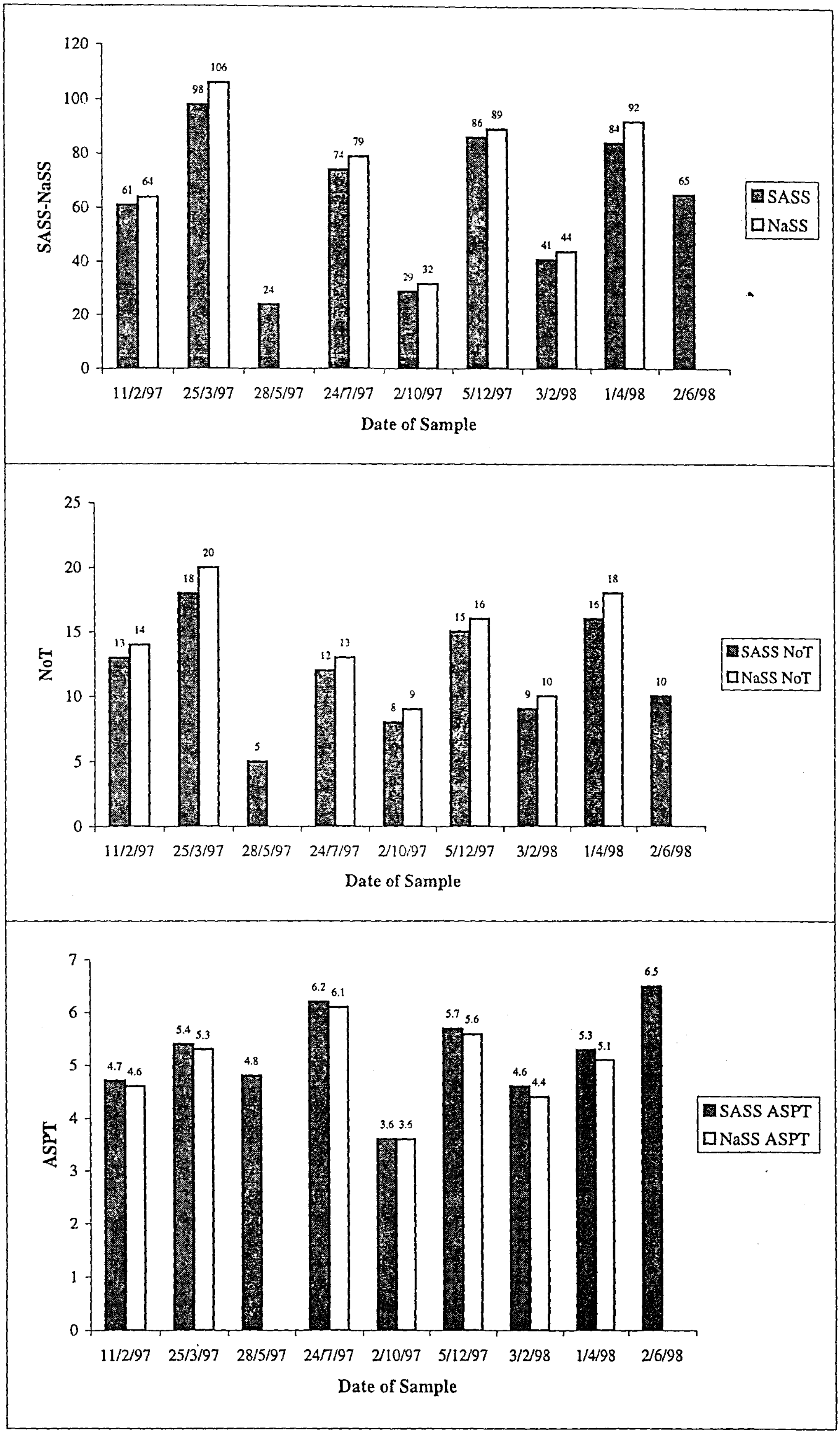


Figure 19 Graphs showing scores for the Silt habitat at Lyadura

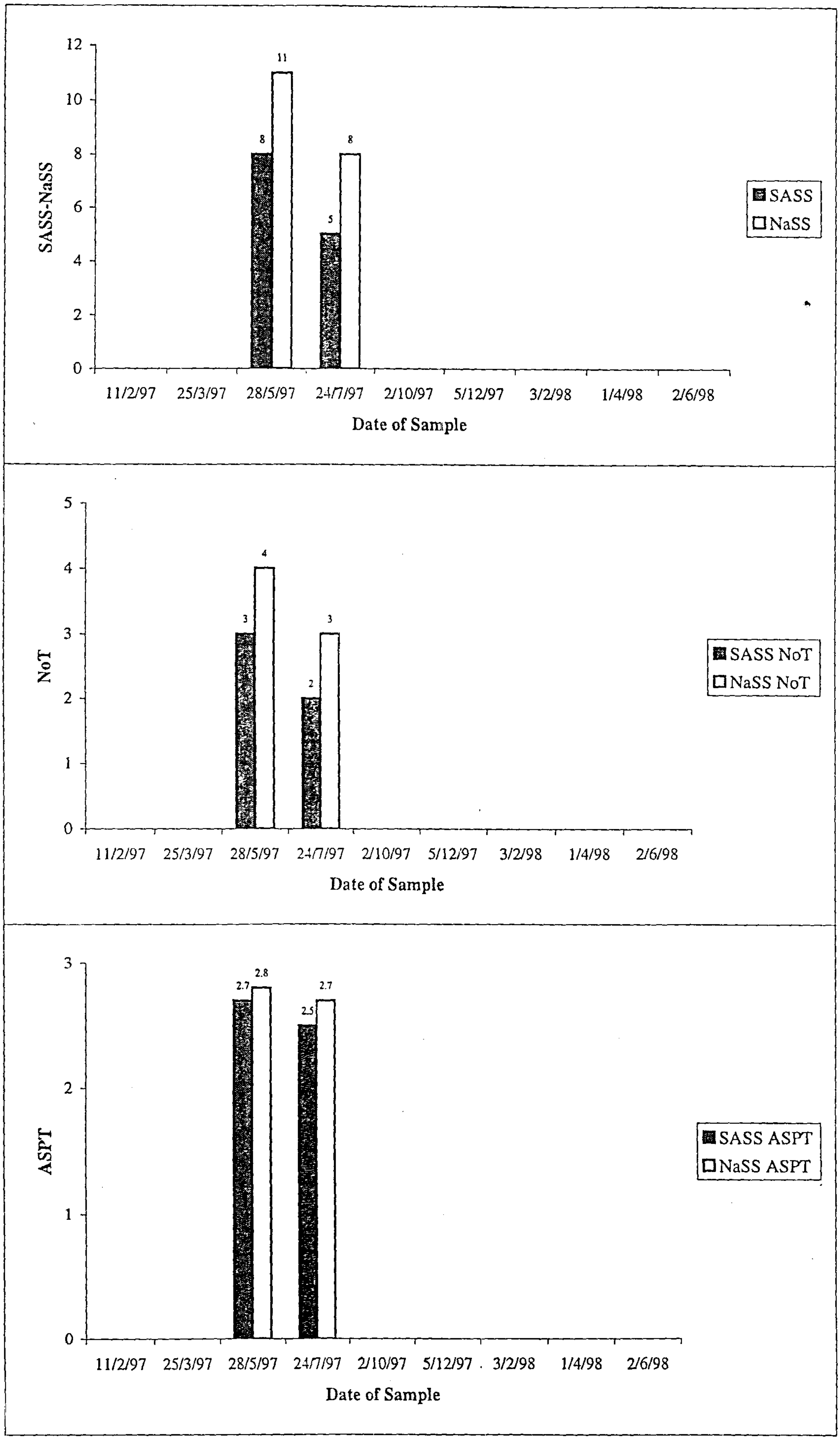


Figure 20 Graphs showing scores for all habitats combined at Lyadura

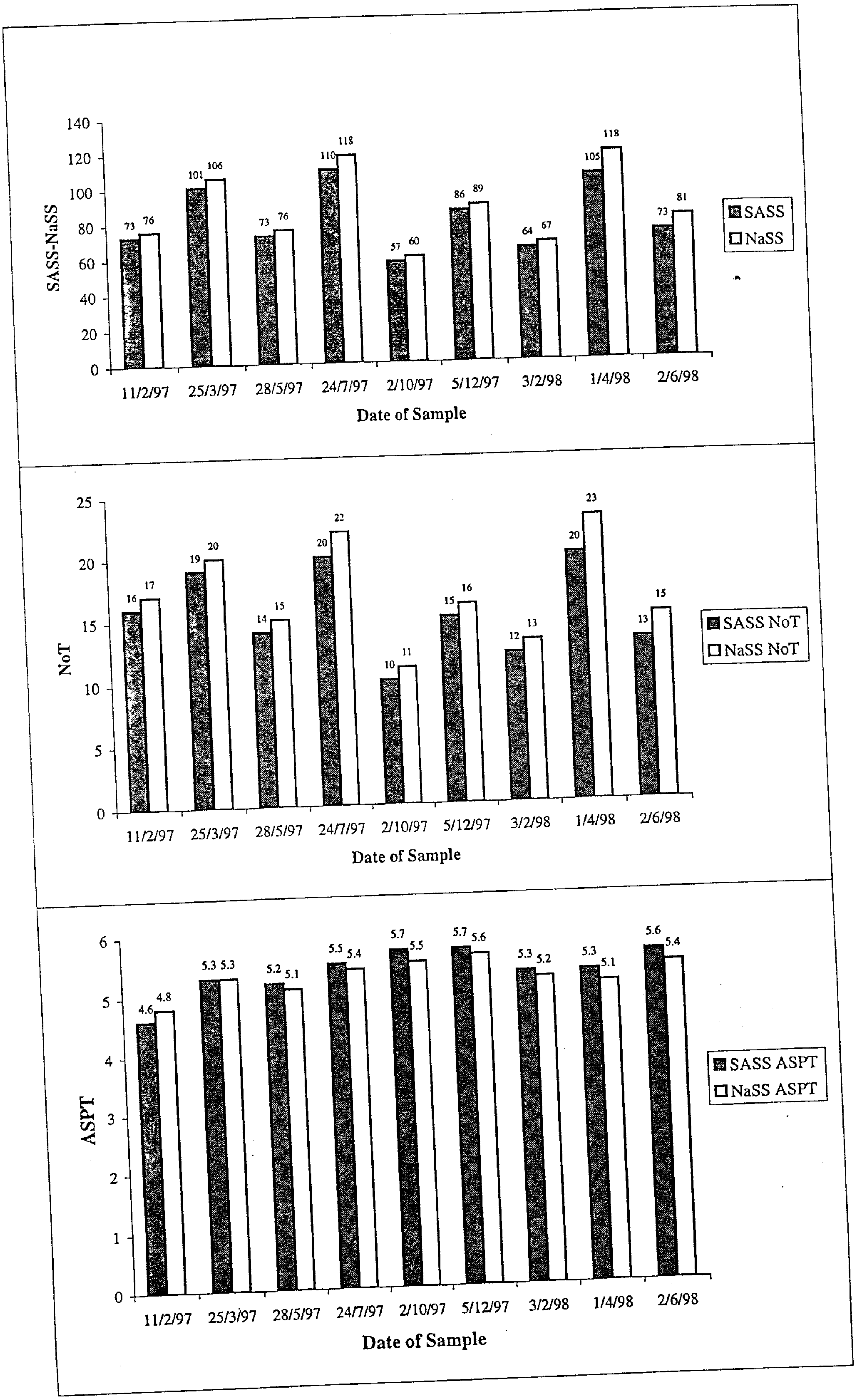


Table 20 **Water Quality scores for Lyadura, Silt habitat**

Date	SASS Score	SASS NoT	SASS ASPT	NaSS Score	NaSS NoT	NaSS ASPT
11/2/97	-	-	-	-	-	-
25/3/97	-	-	-	-	-	-
28/5/97	8	3	2.7	11	4	2.8
24/7/97	5	2	2.5	8	3	2.7
2/10/97	-	-	-	-	-	-
5/12/97	-	-	-	-	-	-
3/2/98	-	-	-	-	-	-
1/4/98	-	-	-	-	-	-
2/6/98	-	-	-	-	-	-

Table 21 **Water Quality scores for Lyadura, All habitats combined**

Date	SASS Score	SASS NoT	SASS ASPT	NaSS Score	NaSS NoT	NaSS ASPT
11/2/97	73	16	4.6	76	17	4.8
25/3/97	101	19	5.3	106	20	5.3
28/5/97	73	14	5.2	76	15	5.1
24/7/97	110	20	5.5	118	22	5.4
2/10/97	57	10	5.7	60	11	5.5
5/12/97	86	15	5.7	89	16	5.6
3/2/98	64	12	5.3	67	13	5.2
1/4/98	105	20	5.3	118	23	5.1
2/6/98	73	13	5.6	81	15	5.4

3.3.3 Chobe River

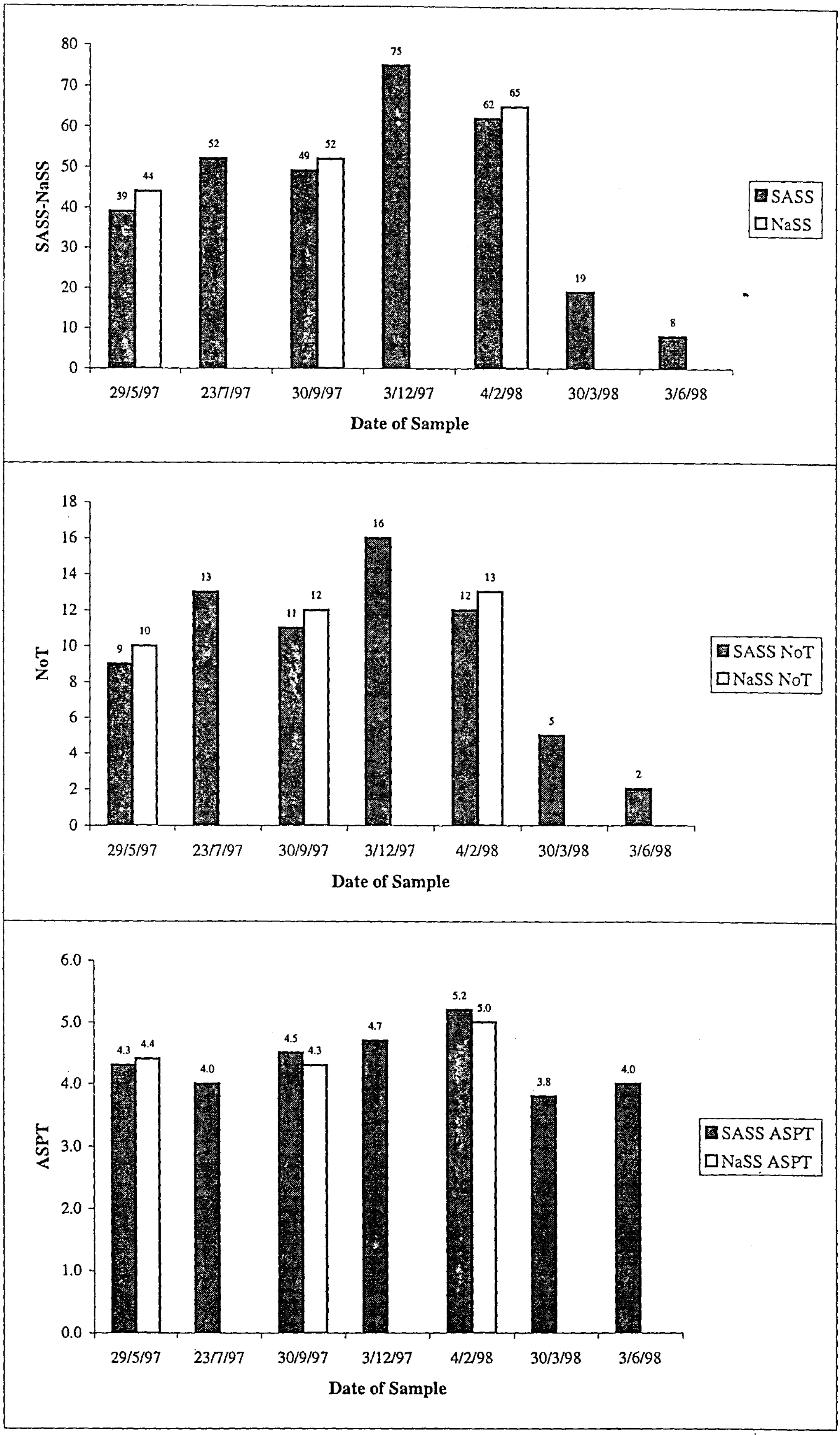
3.3.3.1 Ngoma Bridge

Only one habitat type, MV, was available for sampling at Ngoma. This was available all year round and samples were taken on each designated sampling occasion throughout the study period. The MV habitat consisted predominantly of hippo grass (*Vossia cuspidata*). The list of taxa for the MV habitat at Ngoma bridge is shown in Table 1 in Appendix V. The scores from this habitat are shown in Table 22 and represented graphically in Figure 21.

Table 22 **Water quality scores for Ngoma bridge for the only habitat – Marginal vegetation**

Date	SASS Score	SASS NoT	SASS ASPT	NaSS Score	NaSS NoT	NaSS ASPT
29/5/97	39	9	4.3	44	10	4.4
23/7/97	52	13	4.0	-	-	-
30/9/97	49	11	4.5	52	12	4.3
3/12/97	75	16	4.7	-	-	-
4/2/98	62	12	5.2	65	13	5.0
30/3/98	19	5	3.8	-	-	-
3/6/98	8	2	4.0	-	-	-

Figure 21 Graphs showing scores for the only habitat type (MV) at Ngoma



SASS/NaSS and NoT scores rose steadily between May and September, peaking in December '97. ASPT scores followed a similar trend but peaked later in February 1998. All scores were very low during the flood experienced at this site between March and June 1998. This sample site was characterised by a pool of water in the riverbed, isolated from the main channel throughout the initial part of the study. The pool was heavily fished in the early part of 1997, which would have led to a reduction in the number of predatory fish species. Invertebrates at the site must have bred increasingly rapidly as the year progressed, the habitat became more extensive and the water warmed up. This, combined with the additional lack of predatory pressure from fish, led to an increase in invertebrate richness and abundance. This explained the steady rise in all scores observed during the first eight months or so of the survey.

All scores dropped severely in March and June 1998 due to the extensive flood experienced in the Chobe valley during that time. Water initially flowed rapidly upstream from the Zambezi and then reversed its flow and went downstream back to the main channel. Many species of fish were also triggered into breeding condition by the flood and the water was thus very rapidly filled with fish fry, many feeding on invertebrates. The onset of flow and its subsequent change in the direction combined with the sudden increase in predation pressure had very severe effects on the invertebrate taxa at the site and SASS/NaSS and NoT scores crashed.

SASS/NaSS scores were consistently <100 and often <50, ASPT scores were always <6.0 and somewhat variable. From the description given by Chutter (1998) this would imply that the site suffered from *"some to major deterioration in water quality"*. The pool at which the samples were taken was heavily utilised for the abstraction of water for a road-building programme throughout the study period. It was also adjacent to a borrow pit site used for the extraction of hardcore. Despite these factors, no obvious pollution occurred during the study period and the SASS/NaSS scores etc. showed a steady increase during the period of investigation. The SASS methodology, as with its British predecessor system BMWP, was never really designed to measure pollution in lentic (standing) waters.

The invertebrate fauna occurring in such still water is very different from that in lotic (running) waters, for example many more species are direct air-breathers in the lentic environment than in the lotic environment. In the latter case, dissolved oxygen is directly carried to the gills of the submerged organisms. Invertebrates in the two situations thus respond to pollution in a different ways, particularly organic pollution that affects the quantity of DO in the water. The low scores observed at this site were thus thought to be due to the lentic nature of the site and the single habitat type sampled, rather than due to pollution in the Chobe River. This could only be confirmed by joint chemical and biological sampling at the site in the future.

3.3.3.2 Ihaha

Only Marginal Vegetation was available for sampling at Ihaha between May 1997 and February 199. The whole area was flooded between March and August 1998. The list of taxa for the MV habitat at Ihaha is shown in Table 1 in Appendix VI. The scores from this habitat are shown in Table 23 and represented graphically in Figure 22.

Figure 22 **Graphs showing scores for the only habitat (MV) at Ihaha**

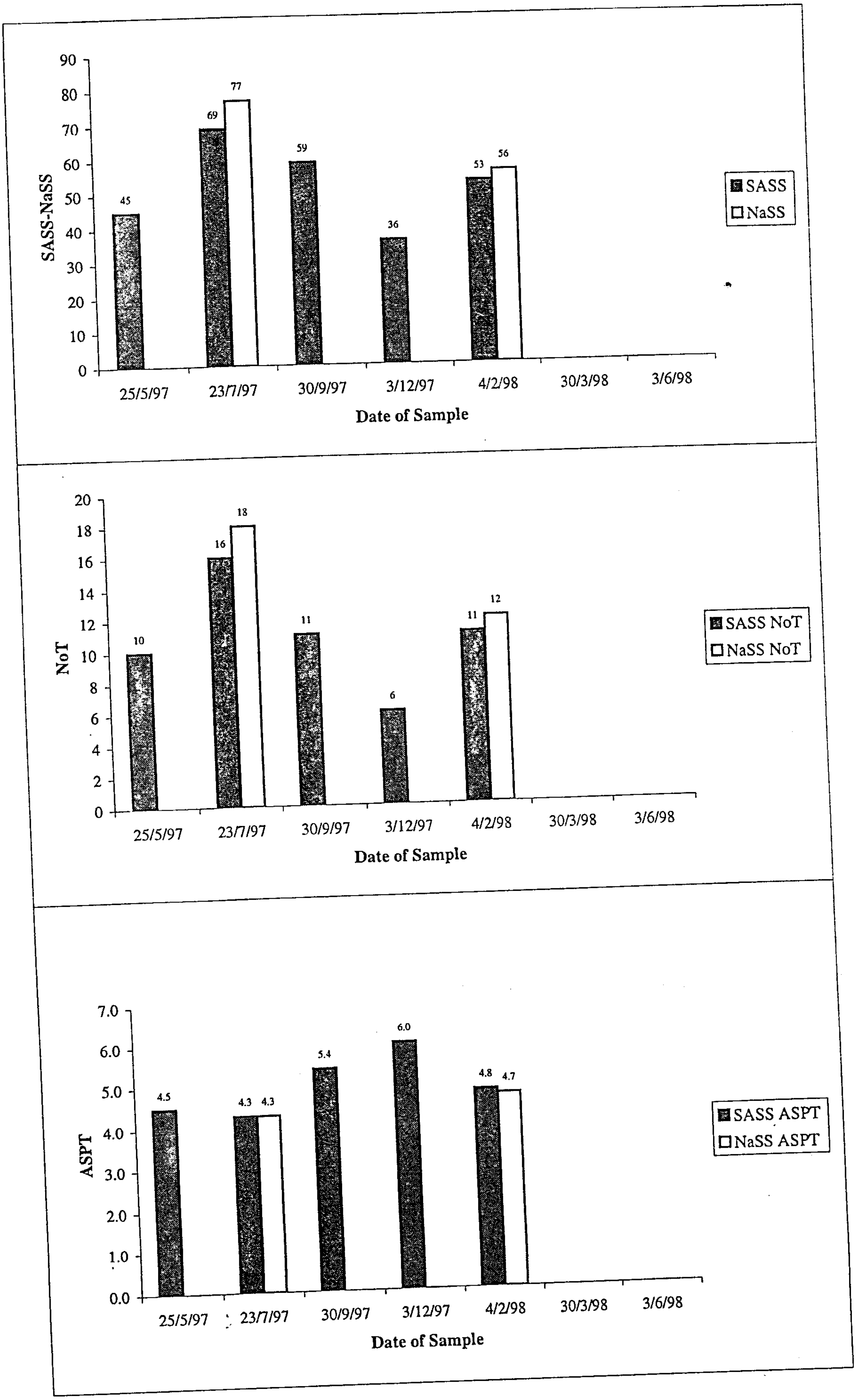


Table 23 **Water quality scores for Ihaha for the only habitat – Marginal vegetation**

Date	SASS Score	SASS NoT	SASS ASPT	NaSS Score	NaSS NoT	NaSS ASPT
29/5/97	45	10	4.5	-	-	-
23/7/97	69	16	4.3	77	18	4.3
30/9/97	59	11	5.4	-	-	-
3/12/97	36	6	6.0	-	-	-
4/2/98	53	11	4.8	56	12	4.7
30/3/98	-	-	-	-	-	-
3/6/98	-	-	-	-	-	-

Due to flooding, the sample taken in May 1997 was not taken in the main channel, but from as close as was possible to it. The MV habitat in this instance consisted solely of recently flooded grassland which accounted for the low score obtained on that occasion. The samples taken between July and December 1997 and in February 1998 were all from the main channel. SASS/NaSS and NoT scores were seen to drop consistently from July to December 1997, the opposite to the effect seen on the same river channel at Ngoma. The reason for this might have been that, unlike the Ngoma site, the Ihaha site was not an isolated pool and was connected to the rest of the Chobe River channel. Also unlike Ngoma, predation by fish on invertebrates was likely to have been high at this site, which may explain the observed drop in SASS/NaSS and NoT scores. The rising ASPT scores showed that a small number of higher scoring taxa were left by the end of the year. SASS/NaSS and NoT scores rose again in February as the flood began to push water, and presumably some invertebrates upstream. ASPT fell at the same time indicating that the newly arrived taxa were numerous but not from high scoring groups.

SASS/NaSS scores were all <100 but only a few were <50 and ASPT scores varied from between 4.3 – 6.0. As with Ngoma, scores indicated that there was some impact on the water quality, but not as severe as that seen at Ngoma. The slightly better scores here were most likely as this was not an isolated pool, connected with the main channel and subject to flow at certain times of year. There was also no abstraction at this site and no other anthropomorphic influences. It is difficult to say whether the water quality was actually better than at Ngoma or just that the site was less affected by external abiotic factors. Again, the only way that this could be confirmed would be to do joint biological and chemical monitoring in the future.

3.3.4 Chobe/Zambezi

3.3.4.1 Ichingo

Due to its distance from Katima this site was not regularly included in the survey until January 1998. Samples were taken from two habitats, namely Stones In Current (SIC) and Aquatic Vegetation (AV) although no SIC could be sampled in April '98 due to the height of the flood. Results from this site are not as comprehensive as for all the other sites sampled but general trends could be determined.

The list of taxa for the AV habitat at Ichingo is shown in Table 1 in Appendix VII. The scores from this habitat are shown in Table 24 and represented graphically in Figure 23.

Table 24 Water quality scores for Ichingo for the habitat – Aquatic Vegetation

Date	SASS Score	SASS NoT	SASS ASPT	NaSS Score	NaSS NoT	NaSS ASPT
29/5/97	-	-	-	-	-	-
7/8//97	55	10	5.5	-	-	-
30/9/97	-	-	-	-	-	-
3/12/97	-	-	-	-	-	-
5/2/98	31	8	3.9	34	9	3.8
2/4/98	-	-	-	-	-	-
4/6/98	27	6	4.5	-	-	-

Four samples were taken from the AV habitat at this site. The observed changes in all scores seemed to be somewhat erratic, with the highest score being recorded at the height of the flood. The AV habitat sampled in August 1997 was very different from that in April 1998, the August '97 sample coming from an unidentified submerged plant on a sand bar in a side-channel and the April '98 from new plant growth at the edge of the main channel during the flood. The samples taken in February and June '98 were from intermediate types of AV habitat which may explain the lower scores observed here. All SASS/NaSS and ASPT scores were <100 and <6.0 respectively but this was thought to be due to sampling from a single habitat and not due to water quality problems. This was confirmed by the scores obtained from the SIC habitat and the combined scores for the site.

The list of taxa for the SIC habitat at Ichingo is shown in Table 2 in Appendix VII. The scores from this habitat are shown in Table 25 and represented graphically in Figure 24.

Table 25 Water quality scores for Ichingo for the habitat – Stones in Current

Date	SASS Score	SASS NoT	SASS ASPT	NaSS Score	NaSS NoT	NaSS ASPT
29/5/97	-	-	-	-	-	-
7/8//97	71	7	10.1	-	-	-
30/9/97	-	-	-	-	-	-
3/12/97	-	-	-	-	-	-
5/2/98	110	13	8.5	113	14	8.1
2/4/98	-	-	-	-	-	-
4/6/98	12	3	4.0	16	4	4.0

As with samples taken from SIC in the Okavango and Zambezi, the lowest scores for SASS/NaSS, NoT and ASPT were recorded just after the flood. The highest SASS/NaSS and NoT scores were recorded in February 1998 but the highest ASPT was recorded in August 1997. SASS/NaSS scores and NoT scores were low here as they came from bedrock which restricted the richness of the fauna, e.g. the SASS/NaSS score for August '98 was <100 but the few taxa found were high scoring, e.g. an ASPT score of 10.1. These data confirmed good water quality and the impoverished nature of bedrock as the only habitat. The sample taken in February '98 had a SASS/NaSS over >100 and an ASPT of >6.0 indicating excellent water quality and habitat, whereas the scores for June '98 were both <100 and <6.0. The June sample was collected just post flood and the fauna had obviously been affected by the high water. Neither water quality nor habitat was thought to be a problem at this site.

Figure 23 Graphs showing scores for the AV habitat at Ichingo

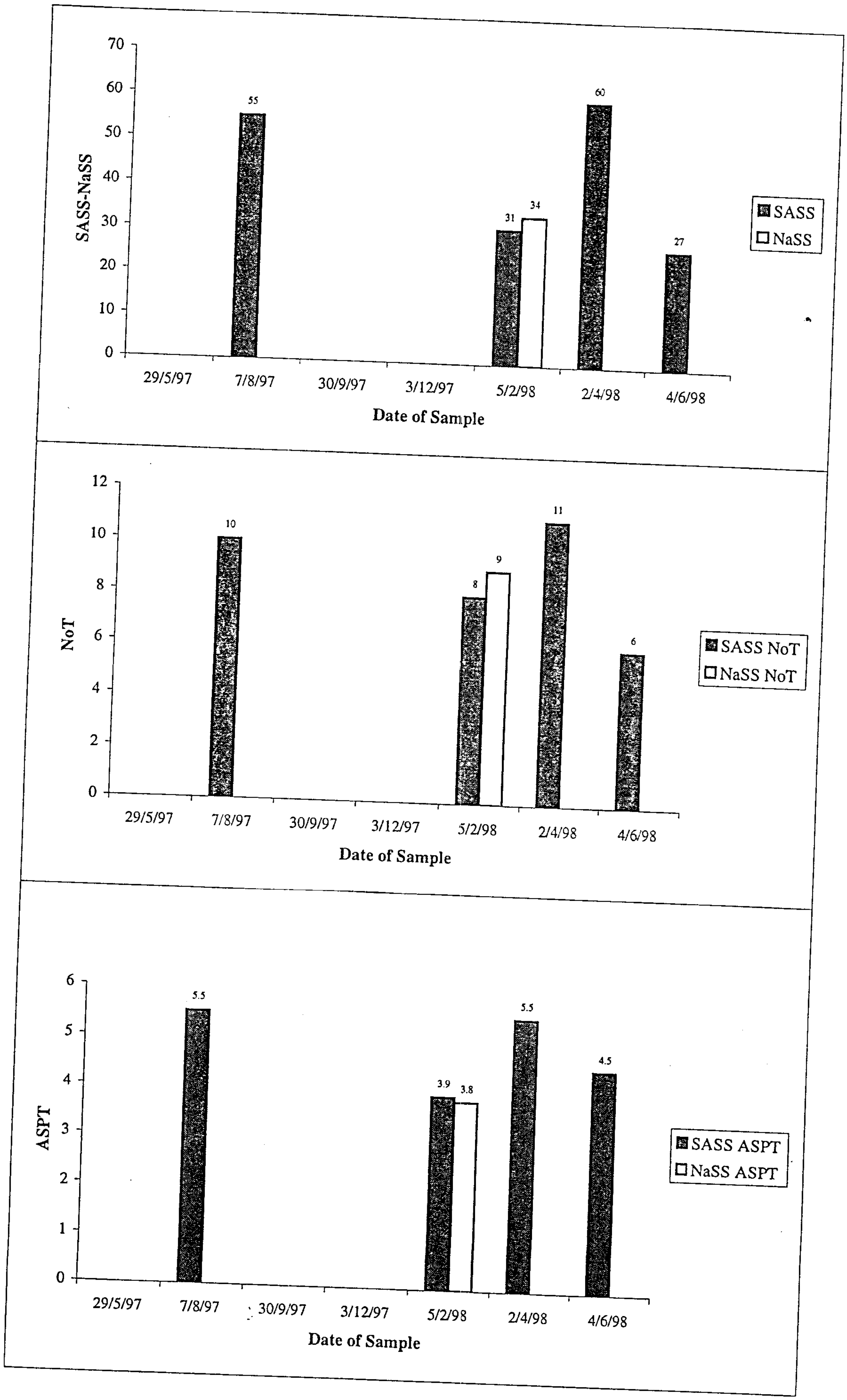
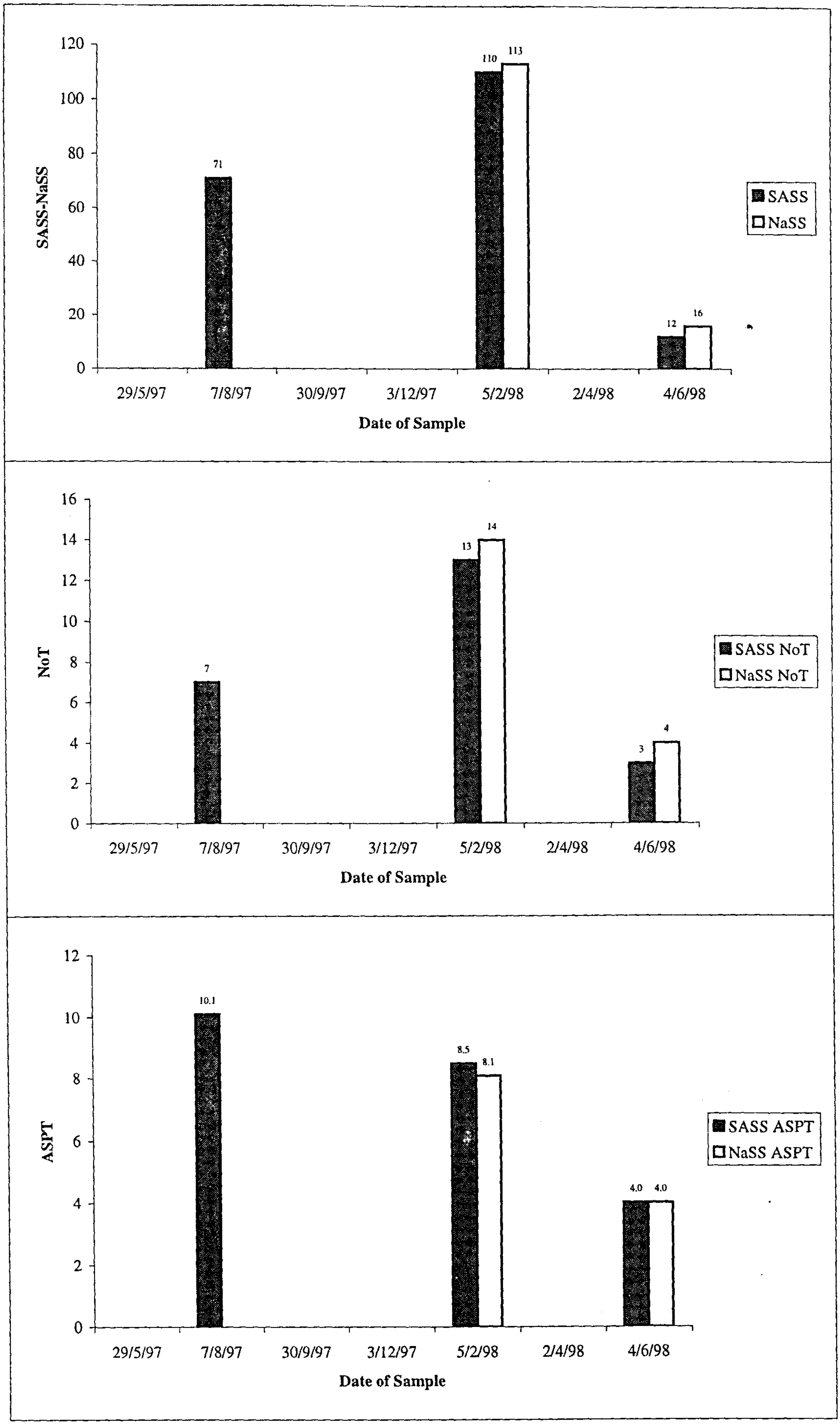


Figure 24 Graphs showing scores for the SIC habitat at Ichingo



The list of taxa for all habitats combined at Ichingo is shown in Table 3 in Appendix VII. The scores from this habitat are shown in Table 26 and represented graphically in Figure 25.

Table 26 Water quality scores for Ichingo for all habitats combined

Date	SASS Score	SASS NoT	SASS ASPT	NaSS Score	NaSS NoT	NaSS ASPT
29/5/97	-	-	-	-	-	-
7/8//97	105	15	8.1	-	-	-
30/9/97	-	-	-	-	-	-
3/12/97	-	-	-	-	-	-
5/2/98	120	16	7.5	126	18	7.0
2/4/98	60	11	5.5	-	-	-
4/6/98	29	6	4.8	33	7	4.7

Combining the tv'o habitats showed a change in scores very similar to that seen for the SIC habitat and for the samples taken at Wenela on the Zambezi and Cheye and Popa Falls on the Okavango. If it is assumed that the scores for 29/5/97 were low, as they were in 4/6/98 then the general trend visible for this site was one of increasing SASS/NaSS and NoT scores between August and December 1997 and then falling scores as the flood occurred. It is also likely, judging from the ASPT score of 8.1 in August, that the highest ASPT score occurred earlier than the highest SASS/NaSS and NoT scores as was the case at the other rapids sites. SASS/NaSS scores outside of the flood season were >100 and ASPT scores >6.0 indicating very good water quality and excellent habitat.

3.3.5 Zambezi River

3.3.5.1 Wenela

Two habitats were available at this site, Stones In Current (SIC) and Marginal Vegetation (MV). No SIC samples were taken in April 1998 as the river level was too high. MV habitat was available in some form all year round. When the river level was high in May 1997 and between February and June 1998, MV samples were taken from inundated terrestrial grasses whereas between August and December 1997 they were taken from a stand of *Vossia cuspidata* adjacent to the main-channel. The list of taxa for the SIC habitat at Wenela is shown in Table 1 in Appendix VIII. The scores from this habitat are shown in Table 27 and represented graphically in Figure 26.

Table 27 Water quality scores for Wenela SIC habitat

Date	SASS Score	SASS NoT	SASS ASPT	NaSS Score	NaSS NoT	NaSS ASPT
12/2/97	64	10	6.4	-	-	-
30/5/97	98	12	8.2	101	13	7.8
8/8/97	115	12	9.6	-	-	-
30/9/97	142	19	7.5	-	-	-
3/12/97	132	17	7.8	135	18	7.5
4/2/98	78	13	6.0	-	-	-
8/4/98	-	-	-	-	-	-
3/6/98	83	10	8.3	-	-	-

Figure 25 **Graphs showing scores for all habitats combined at Ichingo**

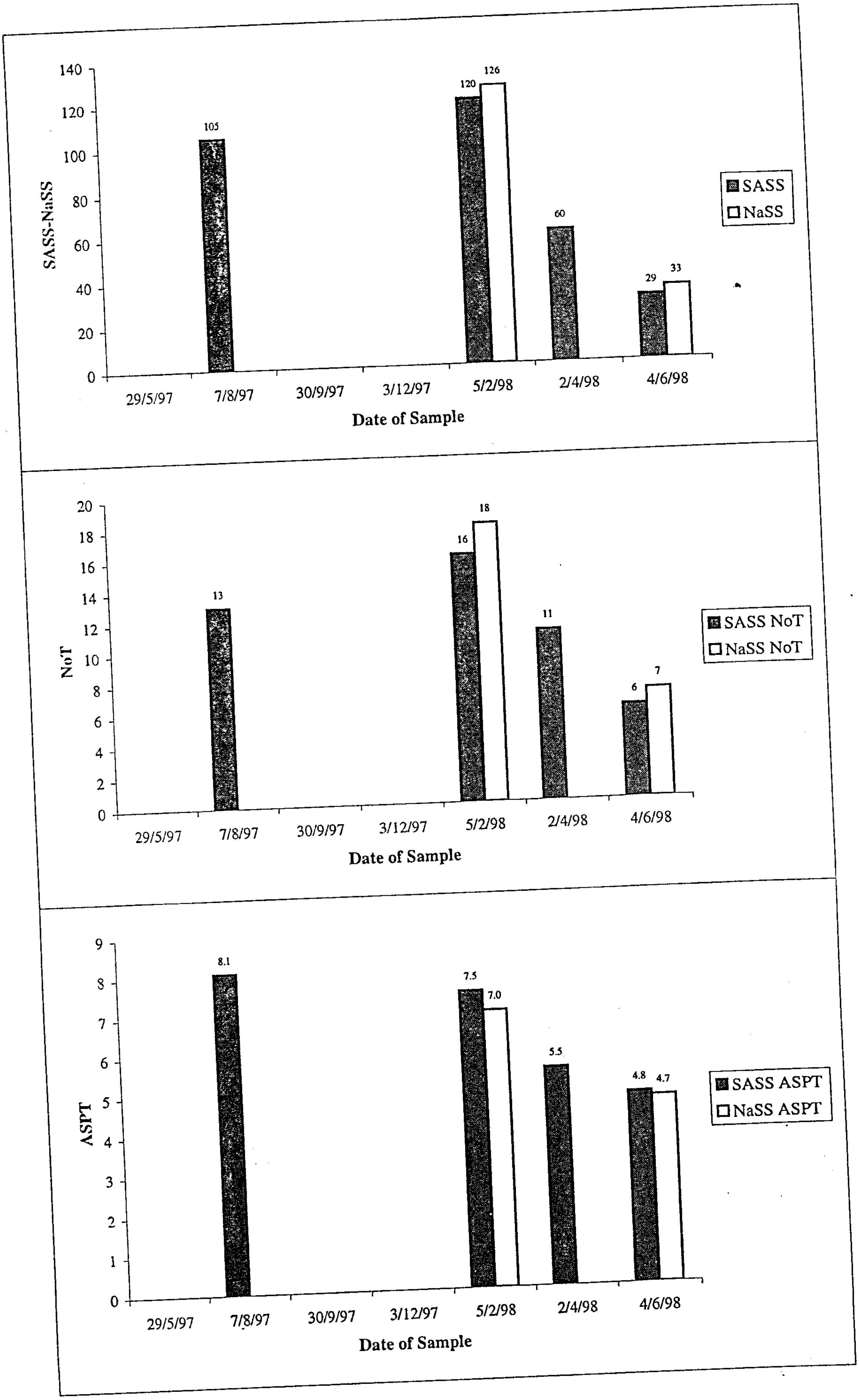
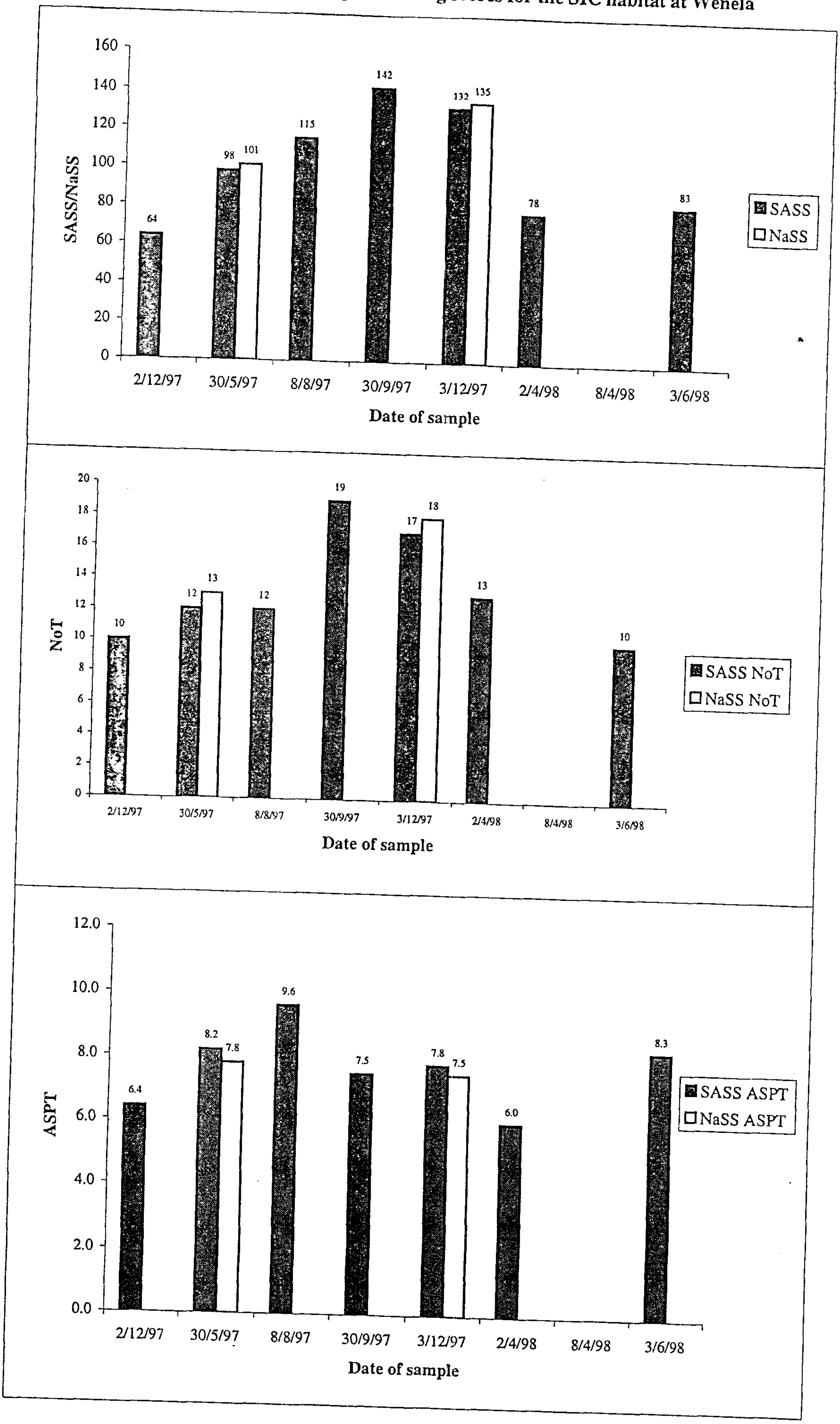


Figure 26 Graphs showing scores for the SIC habitat at Wenela



SASS/NaSS and NoT showed the same trends for the SIC habitat, with scores steadily rising between May and September 1997, there was then a slight drop in December '97 followed by a rapid fall as the river rose and flooded between February and April 1998. No samples could be taken from this habitat in April but SIC was sampled again in June although only at the very edge of the main-channel. This explained the changes observed in these scores over this period. ASPT scores did not follow the exact same pattern as the NoT and SASS/NaSS reaching a peak in August 1998, dropping in September and then rising again in December 1997 before showing the changes caused by increase in river level. As in the Okavango, ASPT scores seem to peak when the water level had dropped but before the water temperature had risen too high. This post flood and pre-summer period of "ASPT high" would thus appear to be a prime time to take samples for water quality assessments. ASPT scores were ≥6.0 for the whole year and SASS/NaSS scores were generally >100 when the river level was low indicating excellent water quality and the importance of the SIC habitat to the invertebrate fauna.

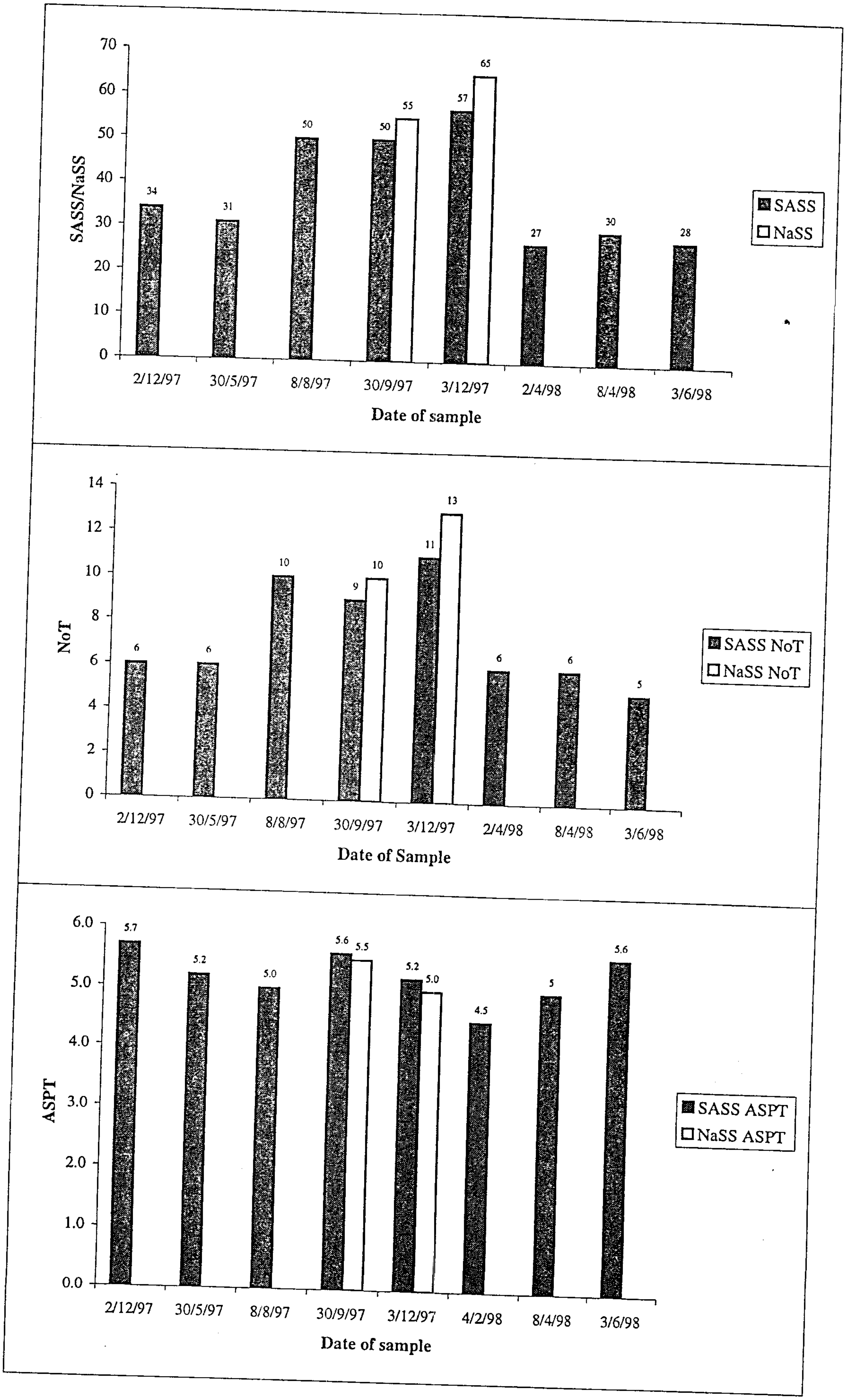
The list of taxa for the MV habitat at Wenela is shown in Table 2 in Appendix VIII. The scores from this habitat are shown in Table 28 and represented graphically in Figure 27.

Table 28 **Water Quality scores for Wenela, Marginal vegetation habitat**

Date	SASS Score	SASS NoT	SASS ASPT	NaSS Score	NaSS NoT	NaSS ASPT
12/2/97	91	14	6.5	94	15	6.3
30/5/97	89	14	6.4	-	-	-
8/8/97	50	10	5.0	-	-	-
30/9/97	50	9	5.6	55	10	5.5
3/12/97	57	11	5.2	65	13	5.0
4/2/98	27	6	4.5	-	-	-
8/4/98	30	6	5.0	-	-	-
3/6/98	28	5	5.6	-	-	-

SASS/NaSS and NoT fell between February and August 1997. This drop was thought to be associated with the fact that samples taken in February and May were from terrestrial grasses growing on a rocky substratum next to the river, they thus included some taxa more typical of the SIC habitat. Samples taken in August, September and December '97 were from "true" MV habitat, i.e. a stand of *Vossia cuspidata*. Scores for this type of MV habitat rose between August and December as recolonisation took place after the flood. Scores dropped for MV habitat between February and June 1998 partly due to the flood and partly because the only MV habitat available during that period was flooded terrestrial grasses.

Figure 27 Graphs showing scores for the MV habitat from Wenela



ASPT scores showed a very similar trend to the SASS/NaSS and NoT scores although the highest score for the *Vossia cuspidata* samples was in September rather than December '97. This could well be explained in the same way as the August "ASPT high" seen in the SIC habitat, i.e. it was caused by a balance between an increasing number of taxa caused by post-flood recolonisation and a decreasing number of high scoring taxa caused by the rising water temperature. SASS/NaSS scores were <100 and ASPT scores generally <6.0. According to Chutter this should indicate a deterioration in water quality but it is thought that this was related purely to the fact that these scores came from a single habitat type. Deterioration in water quality was not indicated in either the scores for the SIC habitat or in the combined SIC and MV scores.

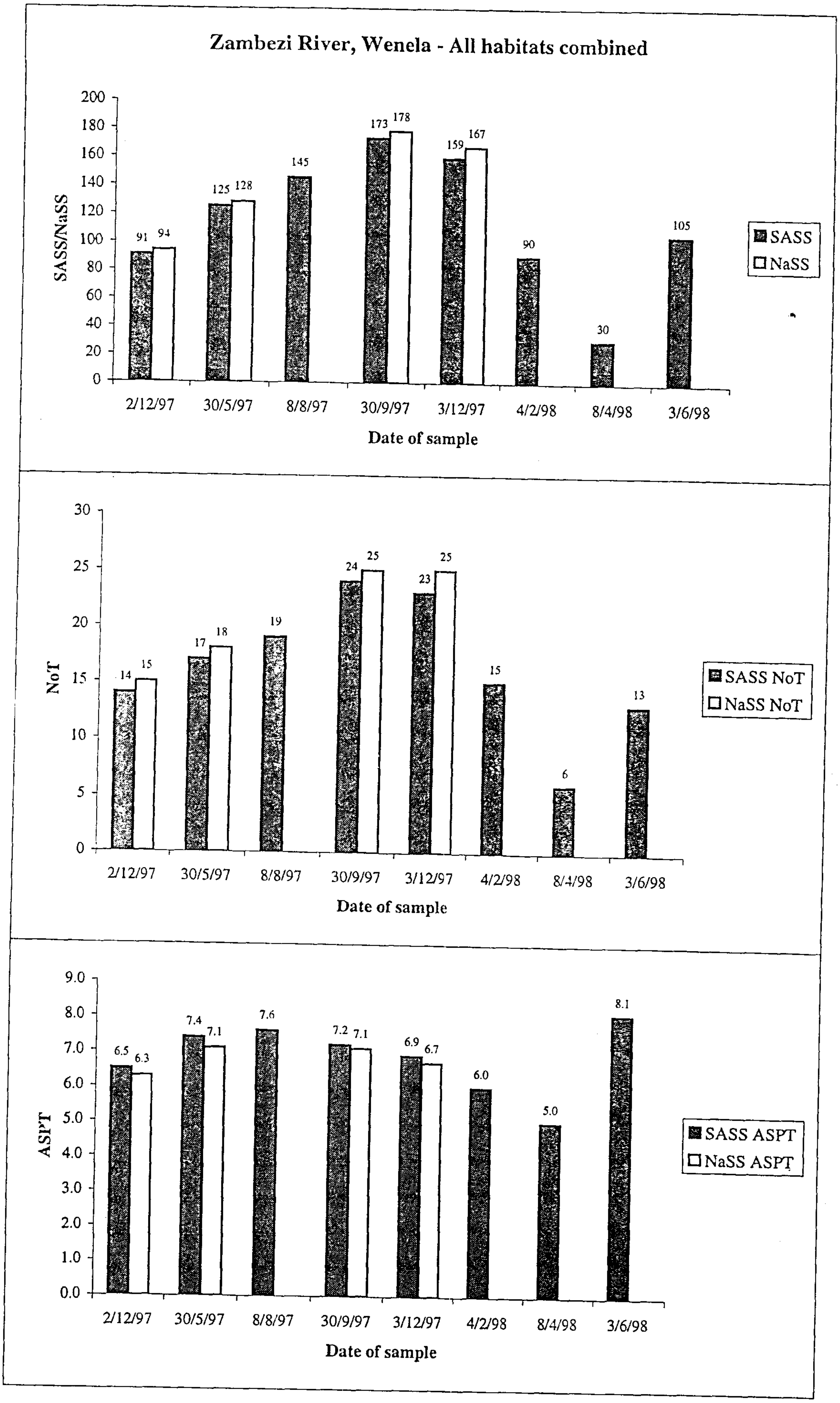
The list of taxa for all habitats combined at Wenela is shown in Table 3 in Appendix VIII. The scores from this habitat are shown in Table 29 and represented graphically in Figure 28.

Table 29 **Water Quality scores for Wenela, All habitats combined**

Date	SASS Score	SASS NoT	SASS ASPT	NaSS Score	NaSS NoT	NaSS ASPT
12/2/97	91	14	6.5	94	15	6.3
30/5/97	125	17	7.4	128	18	7.1
8/8/97	145	19	7.6	-	-	-
30/9/97	173	24	7.2	180	25	7.1
3/12/97	159	23	6.9	167	25	6.7
4/2/98	90	15	6.0	-	-	-
8/4/98	30	6	5.0	-	-	-
3/6/98	105	13	8.1	-	-	-

When both habitats were combined, SASS/NaSS and NoT scores were seen to rise consistently from February and peaked in September '97. This pattern was misleading though as it was likely that scores in fact fell between February and May '97 due to the river flooding during this period but no samples were taken between these dates. Scores then fell between December 1997 and April 1998 before rising again in June after the flood had passed. ASPT scores showed a very similar trend but peaked in August rather than September 1997. Except during the flood, ASPT scores were ≥6.0 and SASS/NaSS scores generally >100 indicating excellent water quality and habitat in the Zambezi at this point.

Figure 28 Graphs showing the scores for all habitats combined at Wenela



3.4 Limitations of the pilot study

3.4.1 Water Chemistry and other abiotic factors

In the project proposal it was stated that certain chemical and other abiotic characteristics of the river at the sampling points would be measured on each sampling occasion, e.g. conductivity, dissolved oxygen, flow rate etc. These measurements were not made for various reasons, including the paucity of working equipment and the expense of chemical analysis of such samples outside of the DWA. Collection of this data should, however, have been done and the lack of such data represents a flaw in the study. Any future biological sampling should be occasionally backed up by chemical sampling. In the UK, chemical samples are taken monthly and changes in the standard chemical parameters, i.e. dissolved oxygen (DO), biological oxygen demand (BOD), nitrate and ammonia are determined by use of three years data combined (in order to give enough samples to be statistically sure of observed changes). Fewer samples are needed for the interpretation of biological data as invertebrate communities are exposed to changes in water chemistry over a longer period and thus effectively have a "built in" statistical significance. Obviously the interpretation of biological data can be further enhanced by the collection of more samples and use of the sort of statistical analysis used by chemists, but this is generally accepted as not being necessary; hence the popularity of biological monitoring.

Some water chemistry data is available from the study rivers from previous work done by the *Salvinia molesta* control team (unpublished data) and Bethune (1991; 1992), but this is not the sort of data that is usually used in a water quality assessment. For example, a typical analysis comprised conductivity, pH, sulphate (SO_4), nitrate (NO_3), nitrite (NO_2), iron (F), chloride (Cl), sodium (Na), potassium (K), calcium (Ca) and turbidity. Little can be deduced about possible pollution in the waterbody from this data, especially at the levels of detection used, where the important criteria, such as NO_3 and NO_2, were not given an exact figure of concentration. An example of this is shown in Table 30.

Table 30 **Typical chemical analysis of water samples from the Kwando river at Balelwa Camp**

Date	Conductivity µS/cm	pH	SO_4 mg/l	NO_3 mg/l	NO_2 mg/l	F mg/l	Cl mg/l	Na mg/l	K mg/l	Ca mg/l	Turbidity
07/09/91	7.4	7.6	<1	1	<0.1	<0.1	3	5	4	15	1
20/02/92	11.6	6.8	4	<0.5	<0.1	<0.1	3	5	6	32	2
18/03/92	11	6.8	4	<0.5	<0.1	<0.1	2	4	6	30	1
10/06/92	8.2	7.9	3	<0.5	<0.1	<0.1	4	5	8	22	2
05/08/92	10.6	8.2	4	<0.5	<0.1	<0.1	3	4	7	35	6
21/10/92	12.8	8	9	<0.5	<0.1	<0.1	3	7	10	30	2
07/03/93	21	7.9	22	<0.5	<0.1	<0.1	3	6	12	77	1

Conductivity and pH measurements were taken from all four river channels sampled during this project in the course of other studies, the results of which are shown in Table 31. Broad changes for some of the other physio-chemical parameters could be reasonably estimated from a good knowledge of the river systems and the seasonal changes observed in these. For example, the temperature of the water in the rivers would have been lower in the winter months (approximately June – August) than at the height of the summer (approximately December – February). Dissolved oxygen (DO) is also known to be at a higher concentration in cooler water and lower in warmer water. The amount of oxygen in the water, and thus available to invertebrates, was thus likely to have been greater in the winter than summer months.

Table 31 **The range of conductivity and pH readings for the Chobe, Kwando, Okavango and Zambezi rivers from samples taken in other studies {Data from Bethune (1991) and unpublished sources}**

Parameter	Chobe	Kwando	Okavango	Zambezi
pH	7.6 – 8.2	6.5 – 8.4	6.8 – 7.2	6.2 – 8.4
µS	8.1 – 166.6	6.5 – 23.2	30 - 45	4.2 – 10
Date	1989 - 1995	1989 - 1995	1984	1989 - 1995

Conductivity and pH generally vary very little in natural, unperturbed flowing water systems and this was generally the case here. The Okavango, Kwando and Zambezi rivers have very few dissolved ions and a low conductivity. The water in the Chobe, and to presumably in the Kwando at Lyadura (no data available for this site), has many more dissolved ions and a higher conductivity due to the slow flowing or stagnant nature of the water. All four rivers are alkaline in nature with the pH > 6, the cut-off point described by Chutter (1998).

3.4.2 Kunene River

Biological monitoring was carried out at sites on the Kunene River on three occasions before, during and after this pilot study in the north-east. Samples were taken in April '97, November '97 and again in November '98. Both November surveys were done in conjunction with a more detailed taxonomic survey of the river and samples from November '98 currently remain with the Albany museum and have thus not been analysed properly. A cursory examination of the data suggests that the Kunene River is also of excellent water and habitat quality in the main channel as the majority of SASS scores were >100 and ASPT scores >6. In side channels, however, a very different picture was seen as SASS scores dropped to <50 in some places and ASPT scores to <6. This was mostly due to the "tidal" effect in the river caused by the hydroelectric scheme at Ruacana (and the daily release of water for power generation). In some places this effect was compounded by the trampling and polluting effects of grazing animals coming down to the river to drink. The samples taken here will be used as part of the baseline study for the Kunene River in any future biological monitoring work done in the area.

3.5 General conclusions

The SASS methodology has been successfully used in determining water quality in the north-eastern perennial rivers of Namibia. A set of meaningful SASS and associated scores were obtained from each designated sampling point over the majority of the study period, the invertebrates collected were successfully identified to a taxonomic level appropriate for the allocation of scores and frequently further. As in South Africa and the UK, the use of biological monitoring seems to have proven to be a reliable, relatively easy and cheap method by which to assess water quality in river systems. The majority of the work was, however, carried out by a highly trained non-Namibian staff member and although the methodology is relatively simple, only suitably trained staff would be able to continue this work. Despite some on the job training that took place in the Caprivi during the pilot study, Namibia still presently lacks personnel able to continue this work and there is a need for further training in the Department of Water Affairs and in the country as a whole.

It was suggested that some changes may need to be made to SASS in order that it reflect the more tropical fauna found in northern Namibian rivers, i.e. creation of NaSS. There are, however, arguments against this. The SASS system as it currently stands and is used in South Africa works well enough without changes and the addition of new taxa has made little significant difference to the overall interpretation of the data collected during this study. A decision will need to be taken as to whether it is more important to take account of the information provided by inclusion of new taxa, and thus change SASS, or for the data to be compatible with that of regional neighbours, and thus leave it alone. This becomes especially true if the sampling programme is broadened and includes the Orange River, for example, it has been suggested that Namibia alone does the sampling for this system and makes the information available to South Africa. Decisions as to whether to include new taxa and change SASS can only be made after further work and collection of more data. A proposal to obtain funding for such research was written by the members of the South African River Health Programme at a SASS workshop held in East London, South Africa, in December 1998. This was due for submission to the Water Research Commission (WRc) in South Africa in January 1999. It is recommended that the data from this study be made available to that research programme should it receive funding.

It was apparent from the results presented here that sampling for biological monitoring should only be carried out at certain times of year, particularly in rivers with a strong flood regime. SASS samples also gave limited information about the ecology of the invertebrate fauna being studied and SASS sampling should not be used as a technique with which to make ecological assessments of riverine ecosystems. Indeed, it might be argued that too much has been read into the data collected during this study in the explanations offered in the previous sections. This can only be justified on the basis that, as this was the first study of it's kind in the area, an attempt was made to get as much information as possible out of the data collected. Sampling on a bi-monthly basis, as was carried out during this research pilot project, would be too often should this method begin to be used for routine monitoring, otherwise its main objectives of being cheap and easy would be compromised. In the UK, only three samples were taken from each watercourse in a calendar year and this provided sufficient data by which to determine quality changes. It is recommended that a similar approach is taken here in Namibia. For rivers with a pronounced annual flood regime, such as the Zambezi and Okavango, samples should be taken just before the river starts to rise at the end of the dry season and as soon as the main channel can be accessed again after the flood. Another sample should be taken at a point equidistant in time between these two. The exact timing for individual sample sites will depend on their geography, e.g. points downstream will be inundated longer than sites upstream and will thus have a different sampling regime. For rivers with no pronounced flood pattern, where samples can physically be taken at anytime of year, it is recommended that sampling be done at the same time, and where possible in conjunction with, other sampling in the area so as to increase efficiency and comparability.

Positioning of future, routine monitoring sampling sites will be driven by two main factors, i.e. water quality and habitat quality. Some sites will want to be chosen for use as reference sites, i.e. sites at which both habitat and water quality is known to be good. Reference sites will be used to make comparisons with sites where there are water quality problems and thus to determine how far these impacted sites have shifted from the reference state. Other sites will be chosen to determine the effects of a certain known or perceived pollutants or other effects on river ecosystems. Such sites will have to be chosen primarily on the position of the perceived problem, but must also take into account things such as habitat diversity, ease of access etc.

Habitat diversity can have a large effect on SASS and ASPT scores, regardless of water quality. For example the SIC habitat at Cheye on 4/12/97 scored 188 whereas the AV habitat, subject to the same quality water produced a score of just 55. To an experienced biologist this is because fast flowing water over stones is the most productive environment in rivers and will thus always score more than submerged weeds. To an untrained eye, however, these differences might be attributed to water quality factors, particularly if the two samples were taken at different sites. Unfortunately, the "habitat effect" is the biggest hurdle to the easy use and interpretation of biological monitoring results and various steps have been taken to try and overcome this. Chutter (1998) suggests that it is best to try and standardise between sampling sites, e.g. each should have samples taken from both marginal vegetation and stones in current, otherwise comparison between sites becomes difficult. This is not always possible, however, and in some cases, e.g. the Kwando River, samples from a single common habitat type, such as MV, might be used for assessment of water quality between sites. The range of acceptable SASS and ASPT scores would then also have to be altered to reflect sampling from a single habitat type. CSIR and the River Health Programme in South Africa have recognised this flaw and some initial research has already been done to develop an adjustment factor that will compensate for variations in habitat between sites. This research is in a very early stage and further funding is currently being sought. A second proposal to carry-out this research was also submitted to the WRc by the members of the South African River Health Programme at the same East London SASS workshop. One of the requests from the researchers involved in this programme at that meeting was that anyone involved in SASS sampling should submit their data to the CSIR for further analysis. Data from this project would be a valuable addition to their work and it is recommended that the results and report be made available to the South African researchers. It is also recommended that, although still someway off, this habitat adjustment factor should be incorporated into the Namibian methodology as soon as it becomes available.

1.4 The way forward

If biological monitoring is to be adopted as a nationally applicable method by which to determine water quality standards and used as a tool with which to manage Namibia's perennial rivers, then some further work needs to be done in the refinement of the method. The Division Water Environment does not currently possess the funds to carry-out such work and external sources need to be found in order to fund this. The sort of work that still needs to be done includes:

- A similar baseline study of the seasonal changes of invertebrate communities on Namibia's other two perennial rivers, namely the Kunene and the Orange.
- Training of Namibian government officials as well as other Namibians, e.g. students in order to build the capacity for such work to be done in the future.
- Determination and justification of sites at which regular and routine biological monitoring should be carried out.

1.5 Budget

The estimated cost of this pilot project (excluding the Kunene River work) was N$60 610 and broke down as shown in Table 32. This project was run by a VSO volunteer and using the existing facilities of the *Salvinia molesta* control programme and this significantly reduced the costs of the programme. It should be noted that to set up a biological monitoring programme run by full-time Namibian government officials would be much more expensive, particularly in the initial stages.

Table 32 **Estimated costs of the pilot study**

Salaries	Capital equipment	Consumables	Training	Transport	S&T	Total
15 310	4 200	1 000	23 000	15 800	1 300	60 610

2 RECOMMENDATIONS

It is recommended that:

1. This report is accepted in principle.
2. The SASS technique can be used in Namibia to make water quality assessments for management purposes.
3. This report is used as the basis from which to formulate a funding proposal to a donor agency in order that the method can be refined and biological monitoring implemented.
4. The results be prepared for publication in one or more scientific journals and be presented at the SASAQS conference in July 1999.
5. Any future routine monitoring programme take cognisance of the suggestions contained in this report.

3 APPROVAL OF RECOMMENDATIONS

This report is approved for submission to the Director: Resource Management.

JS de WET

DEPUTY DIRECTOR: WATER ENVIRONMENT

DATE: 12/2/99

I support the recommendations contained in this report and submit it the Under Secretary for Water Affairs .

Mr. P. Heyns

DIRECTOR: RESOURCE MANAGEMENT

DATE: 16/02/99

The recommendations in this report are approved ~~/ not approved~~

Mr R. Kahuure

PERMANENT SECRETARY FOR MINISTRY OF AGRICULTURE, WATER AND RURAL DEVELOPMENT

DATE: 22/2/99

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The fieldwork would not have been possible, or as safe or enjoyable, without the help, friendship and advice of Mr. Simana who spent many vigilant hours watching for crocodiles and sorting samples on the riverbank. Mr. Makumbi and Mr. Siloiso are also thanked for their diligent help with the sorting of samples in the laboratory.

Most of all though, I would like to thank Kevin Roberts and Shirley Bethune, not only for their professional comment, support and practical help but also for their friendship and generous hospitality throughout the duration of my stay in Namibia.

APPENDICES

APPENDIX I

Table 1 Taxa list for Cheye - Stones in Current habitat

Checklist of macro-invertebrates found at this site (families and *genus* listed alphabetically)	Sample date						
	2/6/97	28/7/97	6/10/97	4/12/97	2/2/98	31/3/98	1/6/98
PHYLUM ANNELIDA							
Class Oligochaeta	#	#	#				
PHYLUM MOLLUSCA							
Class Gastropoda							
Ampullariidae							
Pila occidentalis			#	#			
Bithyniidae							
Gabbiella kisalensis				#			
Class Bivalvia							
Corbiculidae							
Corbicula fluminalis	#	#	#	#			
PHYLUM ARTHROPODA							
Class Crustacea							
Order Decapoda							
Potamonautidae							
Potamonautes bayonianus		#		#			
Class Insecta							
Order Ephemeroptera							
Baetidae							
Afroptilum spp		#					
Baetis spp.		#	#	#			
Demoulinia spp.	#			#			
Pseudopannota spp.		#	#	#			
Caenidae							
Caenis spp.		#					
Heptageniidae							
Afronurus spp.		#	#	#			
Leptophlebiidae							
Choroterpes spp.	#	#	#	#			
Oligoneuridae							
Elassoneuria spp.	#	#	#	#			
Polymitarcidae							
Exeuthyplocia spp.	#	#	#	#			
Tricorythidae							
Tricorythus spp.		#	#	#			
Order Trichoptera							
Ecnomidae (indet.)	#	#					
Hydropsychidae							
Aethaloptera spp.			#				
Amphipsyche spp.				#			
Cheumatopsyche spp.	#	#	#	#			
Macronema spp.		#		#			
Hydroptilidae							
Orthotrichia spp.		#					
Leptoceridae							
Trichosetodes spp.			#				
Philopotamidae (indet.)		#	#				
Order Odonata							
Suborder Anisoptera							
Gomphidae (indet.)	#						
Paragomphus spp.		#	#	#			

Table 1 cont. Taxa list for Cheye - Stones in Current habitat

Checklist of macro-invertebrates found at this site (families and *genus* listed alphabetically)	Sample date						
	2/6/97	28/7/97	6/10/97	4/12/97	2/2/98	31/3/98	1/6/98
Libellulidae (indet.)		#					
Zygonyx spp.			#	#			
Suborder Zygoptera							
Coenagriidae (indet.)	#						
Order Diptera							
Ceratapogonidae		#					
Chironomidae	#	#		#			
Simuliidae		#					
Tabanidae	#	#	#	#			
Order Neuroptera							
Sisyridae							
Sisyra spp.		#					
Order Coleoptera							
Elmidae/Dryopidae		#					
Gyrinidae							
Orectochilus spp.		#					
Order Hemiptera							
Naucoridae (indet.)		#					
Order Lepidoptera							
Pyralidae (indet.)		#					

Table 2 Taxa list for Cheye – Aquatic Vegetation habitat

Checklist of macro-invertebrates found at this site (families and *genus* listed alphabetically)	Sample dates						
	2/6/97	28/7/97	6/10/97	4/12/97	2/2/98	31/3/98	1/6/98
PHYLUM MOLLUSCA							
Class Gastropoda							
Ampullariidae							
Pila occidentalis				#			
Bithyniidae							
Gabbiella kisalensis				#			
Class Bivalvia							
Unionidae							
Unio caffer				#			
PHYLUM ARTHROPODA							
Class Crustacea							
Order Decapoda							
Atyidae							
Caradina nilotica	#	#	#	#			
Class Insecta							
Order Ephemeroptera							
Baetidae							
Baetis spp.	#	#	#	#			#
Demoulinia spp.	#		#	#			#
Caenidae (indet.)		#		#			
Caenis spp.	#						
Heptageniidae							
Afronurus spp.	#	#	#				
Leptophlebiidae							
Choroterpes spp.				#			
Order Trichoptera							
Hydropsychidae	#						
Cheumatopsyche spp.							#
Hydroptilidae							
Catoxyethira fasciata	#						
Order Odonata							
Suborder Anisoptera							
Gomphidae							
Lestinogomphus spp.				#			
Libellulidae							
Zygonyx spp.	#						
Suborder Zygoptera							
Coenagriidae							
Pseudagrion spp.	#	#		#			
Order Diptera							
Chironomidae	#						
Order Coleoptera							
Gyrinidae							
Orectochilus spp.			#				
Order Hemiptera							
Gerridae (indet.)	#	#					
Veliidae (indet.)		#					

Table 3 Taxa list for Cheye – Marginal Vegetation habitat

Checklist of macro-invertebrates found at this site (families and *genus* listed alphabetically)	2/6/97	28/7/97	6/10/97	4/12/97	2/2/98	31/3/98	1/6/98
	Sample dates						
PHYLUM ANNELIDA							
Class Hirudinea							
Glossiphoniidae						#	
PHYLUM MOLLUSCA							
Class Gastropoda							
Thiaridae							
Melanoides victoriae					#		
PHYLUM ARTHROPODA							
Class Crustacea							
Order Decapoda							
Atyidae							#
Caradina nilotica							
Class Insecta							
Order Ephemeroptera							
Baetidae							
Baetis spp.					#		#
Cloeon spp.					#		
Demoulinia spp.						#	
Caenidae (indet.)					#	#	#
Heptageniidae							
Afronurus spp.							#
Polymitarcidae							
Exeuthyplocia spp.							#
Tricorythidae							
Tricorythus spp.					#	#	
Order Trichoptera							
Hydropsychidae							
Cheumatopsyche spp.						#	
Macronema spp.						#	
Hydroptilidae (indet.)						#	
Philopotamidae (indet.)						#	
Order Odonata							
Suborder Anisoptera							
Aeshnidae (indet.)							#
Corduliidae						#	
Gomphidae (indet.)							#
Libellulidae						#	
Trithemis spp.					#		#
Suborder Zygoptera							
Coenagriidae							
Pseudagrion spp.					#	#	#
Order Diptera							
Chironomidae						#	#
Simuliidae						#	
Order Hemiptera							
Naucoridae (indet.)							#
Nepidae (indet.)					#		#
Veliidae (indet.)					#		#
Order Lepidoptera							
Pyralidae							#

Table 4 Taxa list for Cheye – Stones out of Current habitat

Checklist of macro-invertebrates found at this site (families and *genus* listed alphabetically)	Sample dates						
	2/6/97	28/7/97	6/10/97	4/12/97	2/2/98	31/3/98	1/6/98
PHYLUM ANNELIDA							
Class Oligochaeta			#	#			
PHYLUM MOLLUSCA							
Class Gastropoda							
Thiaridae							
Melanoides tuberculata				#			
Class Bivalvia							
Corbiculidae							
Corbicula fluminalis			#				
Unionidae (indet.)		#	#				
PHYLUM ARTHROPODA							
Class Insecta							
Order Ephemeroptera							
Baetidae							
Demoulinia spp.		#					
Pseudopannota spp.		#		#			
Caenidae							
Caenodes spp.		#					
Polymitarcidae							
Exeuthyplocia spp.			#	#			
Order Trichoptera							
Ecnomidae				#			
Hydropsychidae							
Aethaloptera spp.				#			
Hydroptilidae (indet.)		#					
Order Odonata							
Suborder Anisoptera							
Gomphidae							
Paragomphus spp.		#	#				
Order Coleoptera							
Elmidae/Dryopidae			#				
Helodidae (indet.)		#					

Table 5 Complete Taxa list for Cheye – All habitats combined

Checklist of macro-invertebrates found at this site (families and *genus* listed alphabetically)	Sample dates						
	2/6/97	28/7/97	6/10/97	4/12/97	2/2/98	31/3/98	1/6/98
PHYLUM ANNELIDA							
Class Oligochaeta	#	#	#	#			
Class Hirudinea							
Glossiphoniidae						#	
PHYLUM MOLLUSCA							
Class Gastropoda							
Ampullariidae							
Pila occidentalis			#	#		#	
Bithyniidae							
Gabbiella kisalensis				#			
Thiaridae							
Melanoides tuberculata				#		#	
Class Bivalvia							
Corbiculidae							
Corbicula fluminalis	#	#	#	#			
Unionidae (indet.)			#				
Unio caffer				#			
PHYLUM ARTHROPODA							
Class Crustacea							
Order Decapoda							
Potamonautidae							
Potamonautes bayonianus		#		#			
Atyidae							
Caradina nilotica	#	#	#	#			#
Class Insecta							
Order Ephemeroptera							
Baetidae							
Afroptilum spp.		#					
Baetis spp.	#	#	#	#	#	#	#
Cloeon spp.					#	#	
Demoulinia spp.	#		#	#		#	#
Pseudopannota spp.		#	#	#			
Caenidae (indet.)				#	#	#	#
Caenis spp.	#	#					
Caenodes spp.		#					
Heptageniidae							
Afronurus spp.	#	#	#	#			#
Leptophlebiidae							
Choroterpes spp.	#	#	#	#			
Oligoneuridae							
Elassoneuria spp.	#	#	#	#			
Polymitarcidae							
Exeuthyplocia spp.	#	#	#	#			#
Tricorythidae							
Tricorythus spp.		#	#	#	#	#	
Order Trichoptera							
Ecnomidae							
Ecnomus spp.	#	#		#			
Hydropsychidae							
Aethaloptera spp.			#	#			
Amphipsyche spp.				#			
Cheumatopsyche spp.	#	#	#			#	#
Macronema spp.		#		#		#	

Table 5 cont. Complete Taxa list for Cheye – All habitats combined

Checklist of macro-invertebrates found at this site (families and *genus* listed alphabetically)	Sample dates						
	2/6/97	28/7/97	6/10/97	4/12/97	2/2/98	31/3/98	1/6/98
Hydroptilidae (indet.)		#				#	
Catoxyethira fasciata	#						
Orthotrichia spp.		#					
Leptoceridae							
Trichosetodes spp.			#				
Philopotamidae (indet.)		#	#	#		#	
Order Odonata							
Suborder Anisoptera							
Aeshnidae							#
Corduliidae (indet.)						#	
Gomphidae (indet.)	#	#					#
Lestinogomphus spp.				#			
Paragomphus spp.		#	#	#			
Libellulidae (indet.)		#				#	#
Trithemis spp.					#		
Zygonyx spp.	#		#	#			
Suborder Zygoptera							
Coenagriidae							
Pseudagrion spp.	#	#		#	#	#	
Order Diptera							
Ceratapogonidae		#					
Chironomidae	#	#		#		#	#
Simuliidae						#	
Tabanidae	#	#	#	#			
Order Neuroptera							
Sisyridae							
Sisyra spp.		#					
Order Coleoptera							
Elmidae/Dryopidae		#	#				
Gyrinidae							
Orectochilus spp.		#	#				
Helodidae (indet.)		#					
Order Hemiptera							
Gerridae (indet.)	#	#					
Naucoridae (indet.)		#					#
Nepidae (indet.)					#		#
Veliidae (indet.)		#			#		#
Order Lepidoptera							
Pyralidae (indet.)		#					#

APPENDIX II

Table 1 Taxa list for Popa Falls - Stones in Current habitat

Checklist of macro-invertebrates found at this site (families and *genus* listed alphabetically)	Sample dates							
	13/2/97	2/6/97	28/7/97	6/10/97	4/12/97	2/2/98	31/3/98	1/6/98
PHYLUM PLATYHELMINTHES								
Class Turbellaria								
Dugesiidae								
Dugesia spp.				#				
PHYLUM ANNELIDA								
Class Oligochaeta			#	#	#	#		#
PHYLUM MOLLUSCA								
Class Bivalvia								
Corbiculidae								
Corbicula fluminalis	#	#	#	#				
PHYLUM ARTHROPODA								
Class Crustacea								
Order Decapoda								
Potamonautidae								
Potamonautes bayonianus	#	#	#	#	#			
Class Insecta								
Order Ephemeroptera								
Baetidae (indet.)	#							
Afroptilum spp.		#						
Baetis spp.			#	#	#			
Centroptiloides spp.		#						
Demoulinia spp.			#	#				
Ophelmatostoma spp				#	#			
Pseudopannota spp.		#		#	#	#		#
Heptageniidae								
Afronurus spp.	#	#	#	#	#	#		
Leptophlebiidae								
Choroterpes spp.			#	#	#	#		#
Oligoneuridae								
Elassoneuria spp.			#		#			
Polymitarcidae								
Exeuthyplocia spp.		#	#	#	#	#		#
Prosopistomatidae								
Binoculus spp.			#	#	#			
Tricorythidae								
Tricorythus spp.	#	#	#	#	#	#		#
Order Plecoptera								
Perlidae (indet.)	#		#	#	#	#		#
Order Trichoptera								
Ecnomidae								
Ecnomus spp.					#			
Hydropsychidae								
Aethaloptera spp.				#				
Amphipsyche spp.	#	#			#			#
Cheumatopsyche spp.	#	#	#	#	#	#		#
Macronema spp.	#							
Leptoceridae (indet.)	#				#			
Pseudoleptocerus spp.				#	#			
Philopotamidae (indet.)	#	#		#	#	#		#

Table 1 cont. Taxa list for Popa Falls - Stones in Current habitat

Checklist of macro-invertebrates found at this site (families and *genus* listed alphabetically)	Sample dates							
	13/2/97	2/6/97	28/7/97	6/10/97	4/12/97	2/2/98	31/3/98	1/6/98
Order Odonata								
Suborder Anisoptera								
Gomphidae (indet.)	#				#			
Lestinogomphus spp.								
Paragomphus spp.						#		
Libellulidae (indet.)	#							#
Trithemis spp.						#		
Suborder Zygoptera								
Chlorocyphidae								
Platycypha spp.			#	#				
Order Diptera								
Ceratapogonidae				#				
Chironomidae	#		#					
Simuliidae	#	#		#	#	#		
Tabanidae	#		#		#	#		#
Order Coleoptera								
Elmidae/Dryopidae				#				
Gyrinidae								
Orectochilus spp.					#			

Table 2 Taxa list for Popa Falls – Marginal vegetation habitat

Checklist of macro-invertebrates found at this site (families and *genus* listed alphabetically)	Sample dates							
	13/2/97	2/6/97	28/7/97	6/10/97	4/12/97	2/2/98	31/3/98	1/6/98
PHYLUM MOLLUSCA								
Class Bivalvia								
Corbiculidae								
Corbicula fluminalis					#			
PHYLUM ARTHROPODA								
Class Crustacea								
Order Decapoda								
Potamonautidae								
Potamonautes bayonianus								#
Class Insecta								
Order Ephemeroptera								
Baetidae								
Baetis spp.	#	#	#	#	#	#	#	#
Cloeon spp.				#				
Demoulinia spp.			#		#		#	
Pseudopannota spp.		#						
Caenidae (indet.)					#			
Afrocaenis spp.				#			#	
Caenis spp.		#						
Caenospella spp.			#					
Heptageniidae								
Afronurus spp.	#					#	#	
Leptophlebiidae								
Adenophlebioides spp.				#				
Oligoneuridae								
Elassoneuria spp.					#			
Tricorythidae								
Dicercomyzon spp.					#			
Tricorythus spp.					#			
Order Trichoptera								
Hydropsychidae								
Amphipsyche spp.					#			
Cheumatopsyche spp.		#			#			#
Hydroptilidae								
Hydroptila spp.							#	
Leptoceridae								
Oecetis spp.					#		#	
Parasetodes spp.				#				
Philopotamidae		#						#
Order Odonata								
Suborder Anisoptera								
Gomphidae								
Ictinogomphus spp.				#				
Libellulidae (indet.)								
Orthetrum spp.				#				
Trithemis spp.						#		
Zygonyx spp		#						
Suborder Zygoptera								
Coenagriidae								
Pseudagrion spp.		#	#				#	
Order Diptera								
Chironomidae			#	#	#		#	#
Simuliidae	#	#			#	#		#

Table 2 cont. Taxa list for Popa Falls – Marginal vegetation habitat

Checklist of macro-invertebrates found at this site (families and *genus* listed alphabetically)	Sample dates							
	13/2/97	2/6/97	28/7/97	6/10/97	4/12/97	2/2/98	31/3/98	1/6/98
Order Coleoptera								
Dytiscidae - Laccophilinae				#			#	
Elmidae/Dryopidae				#	#			
Gyrinidae								
Orectochilus spp.			#	#				#
Hydrophilidae								
Enochrus spp.				#				
Order Hemiptera								
Naucoridae (indet.)		#	#	#	#	#		
Gerridae								#
Veliidae			#	#				

Table 3 Taxa list for Popa Falls – Sand habitat

Checklist of macro-invertebrates found at this site (families and *genus* listed alphabetically)	Sample dates 13/2/97	2/6/97	28/7/97	6/10/97	4/12/97	2/2/98	31/3/98	1/6/98
PHYLUM ANNELIDA								
Class Oligochaeta		#				#		
PHYLUM MOLLUSCA								
Class Bivalvia								
Corbiculidae								
Corbicula fluminalis				#				
PHYLUM ARTHROPODA								
Class Insecta								
Order Ephemeroptera								
Baetidae								
Demoulinia spp.						#		
Caenidae								
Afrocaenis spp.				#				
Leptophlebiidae								
Choroterpes spp.						#		
Tricorythidae								
Tricorythus spp.		#						
Order Trichoptera								
Ecnomidae (indet.)					#			
Hydroptilidae								
Catoxyethira fasciata						#		
Order Odonata								
Suborder Anisoptera								
Gomphidae								
Lestinogomphus spp.				#				
Paragomphus spp.						#		
Suborder Zygoptera								
Coenagriidae								
Pseudagrion spp.				#				
Chlorocyphidae								
Platycypha spp.						#		
Order Diptera								
Chironomidae		#		#				
Order Coleoptera								
Elmidae/Dryopidae		#						

Table 4 Complete Taxa list for Popa Falls – All habitats combined

Checklist of macro-invertebrates found at this site (families and *genus* listed alphabetically)	Sample dates							
	13/2/97	2/6/97	28/7/97	6/10/97	4/12/97	2/2/98	31/3/98	1/6/98
PHYLUM PLATYHELMINTHES								
Class Turbellaria								
Dugesiidae								
Dugesia spp.				#				
PHYLUM ANNELIDA								
Class Oligochaeta			#	#	#	#		#
PHYLUM MOLLUSCA								
Class Bivalvia								
Corbiculidae								
Corbicula fluminalis	#	#	#	#	#	#		
PHYLUM ARTHROPODA								
Class Crustacea								
Order Decapoda								
Potamonautidae								
Potamonautes bayonianus	#	#	#	#	#			#
Class Insecta								
Order Plecoptera								
Perlidae (indet.)	#		#	#	#	#		#
Order Ephemeroptera								
Baetidae								
Afroptilum spp.		#						
Baetis spp.	#	#	#	#	#	#		
Cloeon spp.				#				
Centroptiloides spp.		#						
Demoulinia spp.			#	#	#	#	#	
Ophelmatostoma spp				#	#			
Pseudopannota spp.		#		#	#	#	#	#
Caenidae (indet.)					#			
Afrocaenis spp.				#			#	
Caenis spp.		#						
Caenospella spp.			#					
Heptageniidae								
Afronurus spp.	#	#	#	#	#	#	#	
Leptophlebiidae								
Choroterpes spp.			#	#	#	#		#
Oligoneuridae								
Elassoneuria spp.			#		#			
Polymitarcidae								
Exeuthyplocia spp.		#	#	#	#	#		#
Prosopistomatidae								
Binoculus spp.			#	#	#			
Tricorythidae								
Dicercomyzon spp.					#			
Tricorythus spp.	#	#	#	#	#	#		#
Order Trichoptera								
Ecnomidae (indet.)					#			
Ecnomus spp.								
Hydropsychidae								
Aethaloptera spp.	#			#				
Amphipsyche spp.	#	#			#			#
Cheumatopsyche spp.	#	#	#	#	#	#		#
Macronema spp.								

Table 4 cont. Complete Taxa list for Popa Falls – All habitats combined

Checklist of macro-invertebrates found at this site (families and *genus* listed alphabetically)	Sample dates							
	13/2/97	2/6/97	28/7/97	6/10/97	4/12/97	2/2/98	31/3/98	1/6/98
Hydroptilidae								
Catoxyethira fasciata						#		
Hydroptila spp.							#	
Leptoceridae (indet.)	#				#			
Oecetis spp.					#		#	
Parasetodes spp.				#				
Pseudoleptocerus spp.				#	#			
Philopotamidae (indet.)	#	#		#	#	#		#
Order Odonata								
Suborder Anisoptera								
Gomphidae (indet.)	#				#			
Ictinogomphus spp.				#				
Lestinogomphus spp.				#				
Paragomphus spp.						#		
Libellulidae (indet.)	#							#
Trithemis spp.						#		
Orthetrum spp.				#				
Zygonyx spp.		#						
Suborder Zygoptera								
Chlorocyphidae								
Platycypha spp.			#	#		#		
Coenagriidae								
Pseudagrion spp.		#	#	#			#	
Order Diptera								
Ceratapogonidae				#				
Chironomidae	#		#	#	#		#	#
Simuliidae	#	#		#	#	#		#
Tabanidae	#	#	#		#	#		#
Order Coleoptera								
Dytiscidae								
Laccophilinae				#			#	
Elmidae/Dryopidae				#	#			
Gyrinidae								
Orectochilus spp.			#	#	#			#
Hydroptilidae								
Enochrus spp.				#				
Order Hemiptera								
Naucoridae (indet.)		#	#	#	#	#		
Gerridae (indet.)								#
Veliidae (indet.)			#	#				

APPENDIX III

Table 1 Taxa list for Kongola Bridge – Stones In Current habitat

Checklist of macro-invertebrates found at this site (families and *genus* listed alphabetically)	Sample dates							
	10/2/97	27/5/97	24/7/97	1/10/97	5/12/97	3/2/98	1/4/98	2/6/98
PHYLUM ANNELIDA								
Class Oligochaeta	#				#	#	#	
PHYLUM MOLLUSCA								
Class Gastropoda		#						
Thiaridae	#							
Melanoides tuberculata	#							
Planorbidae								
Bulinus spp.			#					
Class Bivalvia		#						
Corbiculidae								
Corbicula fluminalis	#	#	#			#	#	#
PHYLUM ARTHROPODA								
Class Crustacea								
Order Decapoda								
Potamonautidae								
Potamonautes bayonianus	#	#						#
Atyidae								
Caradina nilotica	#		#				#	
Order Ephemeroptera								
Baetidae								
Baetis spp.	#	#	#	#	#		#	#
Demoulinia spp.					#	#		
Ophelmatostoma spp.	#	#		#		#		
Caenidae								
Caenodes spp.		#	#				#	
Leptophlebiidae								
Choroterpes spp.			#		#			
Oligoneuridae								
Elassoneuria spp.	#					#		
Polymitarcidae								
Exeuthyplocia spp.								#
Tricorythidae								
Tricorythus spp.	#	#	#		#	#		
Order Trichoptera								
Ecnomidae		#					#	
Hydropsychidae								
Aethaloptera spp.		#			#		#	#
Amphipsyche spp.		#						#
Cheumatopsyche spp.		#	#	#	#	#	#	#
Philopotamidae (indet.)	#	#	#	#	#	#	#	#
Order Odonata								
Suborder Anisoptera								
Gomphidae (indet.)	#		#		#		#	#
Paragomphus spp.		#				#		
Libellulidae (indet.)							#	
Suborder Zygoptera								
Coenagriidae								
Pseudagrion spp.		#					#	

Table 1 cont. Taxa list for Kongola Bridge – Stones In Current habitat

Checklist of macro-invertebrates found at this site (families and *genus* listed alphabetically)	Sample dates							
	10/2/97	27/5/97	24/7/97	1/10/97	5/12/97	3/2/98	1/4/98	2/6/98
Order Diptera								
Chironomidae	#	#	#	#		#	#	
Culicidae	#							
Simuliidae		#		#		#		
Tabanidae		#	#				#	#
Order Coleoptera								
Dytiscidae							#	
Elmidae/Dryopidae		#			#	#		
Gyrinidae								
Orectochilus spp.	#			#	#	#	#	#
Order Hemiptera								
Nepidae (indet.)	#							
Veliidae (indet.)	#							

Table 2 Taxa list for Kongola Bridge – Aquatic Vegetation habitat

Checklist of macro-invertebrates found at this site (families and *genus* listed alphabetically)	Sample dates							
	10/2/97	27/5/97	24/7/97	1/10/97	5/12/97	3/2/98	1/4/98	2/6/98
PHYLUM ANNELIDA								
Class Oligochaeta						#		
PHYLUM MOLLUSCA								
Class Gastropoda								
Thiaridae								
Melanoides tuberculata			#	#	#	#		#
Planorbidae								
Bulinus spp.			#					#
Bulinus depressus					#			
Gyraulus costulatus					#			
Class Bivalvia								
Corbiculidae								
Corbicula fluminalis			#	#	#			
Unionidae (indet.)							#	#
PHYLUM ARTHROPODA								
Class Crustacea								
Order Decapoda								
Potamonautidae								
Potamonautes bayonianus								#
Atyidae								
Caradina nilotica		#	#	#	#		#	#
Order Ephemeroptera								
Baetidae								
Baetis spp.		#	#	#	#	#	#	#
Demoulinia spp.		#		#	#	#		
Caenidae (indet.)					#			#
Caenodes spp.		#	#	#				
Polymitarcidae								
Povilla spp.						#		
Tricorythidae								
Dicercomyzon spp.						#		
Order Trichoptera								
Ecnomidae							#	
Hydropsychidae								
Cheumatopsyche spp.			#					
Leptoceridae (indet.)							#	
Oecetis spp.		#		#				
Parasetodes spp.				#				
Trichosetodes spp.					#			
Philopotamidae (indet.)				#		#		
Order Odonata								
Suborder Anisoptera								
Gomphidae (indet.)							#	#
Libellulidae (indet.)				#			#	#
Suborder Zygoptera								
Coenagriidae								
Pseudagrion spp.		#	#	#	#	#	#	#
Trithemis spp.		#				#		
Order Diptera								
Chironomidae				#			#	#
Simuliidae		#						
Order Hemiptera								
Naucoridae		#						
Nepidae				#				
Order Lepidoptera								
Pyralidae		#						

Table 3 Taxa list for Kongola Bridge – Marginal Vegetation habitat

Checklist of macro-invertebrates found at this site (families and *genus* listed alphabetically)	Sample dates							
	10/2/97	27/5/97	24/7/97	1/10/97	5/12/97	3/2/98	1/4/98	2/6/98
PHYLUM ANNELIDA								
Class Oligochaeta								#
PHYLUM MOLLUSCA								
Class Gastropoda								
Lymnaeidae								
Lymnaea spp.					#			
Thiaridae								
Melanoides tuberculata					#	#		
Planorbidae								
Bulinus spp.				#				
Gyraulus costulatus				#				
Class Bivalvia								
Corbiculidae								
Corbicula fluminalis				#	#			
Unionidae (indet.)								
Unio caffer					#			
PHYLUM ARTHROPODA								
Class Crustacea								
Order Decapoda								
Potamonautidae								
Potamonautes bayonianus					#			
Atyidae								
Caradina nilotica		#	#	#	#	#	#	#
Class Insecta								
Order Ephemeroptera								
Baetidae								
Baetis spp.	#		#	#				
Centroptilum spp.	#	#	#				#	
Cloeon spp.				#				
Demoulinia spp.					#	#		
Caenidae (indet.)						#	#	
Afrocaenis spp.		#		#				
Heptageniidae								
Afronurus spp.		#						
Polymitarcidae								
Povilla spp.					#			
Tricorythidae								
Dicercomyzon spp.				#	#			
Order Trichoptera								
Hydropsychidae								
Cheumatopsyche spp.						#		
Leptoceridae (indet.)								
Oecetis spp.						#		
Order Odonata								
Suborder Anisoptera								
Gomphidae (indet.)								
Libellulidae (indet.)	#				#		#	#
Trithemis spp.				#		#		
Suborder Zygoptera								
Coenagriidae								
Pseudagrion spp.	#	#	#	#	#	#	#	#
Order Diptera								
Chironomidae	#		#	#		#	#	

Table 3 cont. Taxa list for Kongola Bridge – Marginal Vegetation habitat

Checklist of macro-invertebrates found at this site (families and *genus* listed alphabetically)	Sample dates							
	10/2/97	27/5/97	24/7/97	1/10/97	5/12/97	3/2/98	1/4/98	2/6/98
Order Coleoptera								
Dytiscidae (indet.)					#			
Hyphydrus spp.			#				#	
Gyrinidae								
Orectochilus spp.					#	#		
Hydrophilidae (indet.)		#						
Hydrous spp.		#						
Noteridae								
Canthydrus spp.				#				
Order Hemiptera								
Gerridae			#					
Nepidae				#	#			
Veliidae		#	#	#				

Table 4 Complete Taxa list for Kongola Bridge – All habitats combined

Checklist of macro-invertebrates found at this site (families and *genus* listed alphabetically)	Sample dates							
	10/2/97	27/5/97	24/7/97	1/10/97	5/12/97	3/2/98	1/4/98	2/6/98
PHYLUM ANNELIDA								
Class Oligochaeta	#				#	#	#	#
PHYLUM MOLLUSCA								
Class Gastropoda								
Lymnaeidae								
Lymnaea spp.					#			
Thiaridae								
Melanoides tuberculata	#		#	#	#	#		#
Planorbidae								
Gyraulus costulatus				#	#			
Bulinus spp.			#	#	#			#
Class Bivalvia								
Corbiculidae								
Corbicula fluminalis	#	#	#	#	#	#	#	#
Unionidae								
Unio caffer					#		#	#
PHYLUM ARTHROPODA								
Class Crustacea								
Order Decapoda								
Potamonautidae								
Potamonautes bayonianus	#	#			#			#
Atyidae								
Caradina nilotica	#	#	#	#	#	#	#	#
Order Ephemeroptera								
Baetidae								
Baetis spp.	#	#	#	#	#	#	#	#
Centroptilum spp.	#	#	#					
Cloeon spp.				#				
Demoulinia spp.		#		#	#	#		
Ophelmatostoma spp.	#	#		#		#		
Caenidae (indet.)					#	#	#	#
Afrocaenis spp.		#		#				
Caenodes spp.		#	#	#				
Heptageniidae								
Afronurus spp.		#						
Leptophlebiidae								
Choroterpes spp.			#		#			
Oligoneuridae								
Elassoneuria spp.	#					#		
Polymitarcidae								
Exeuthyplocia spp.								#
Povilla spp.					#	#		#
Tricorythidae								
Dicercomyzon spp.				#	#	#		
Tricorythus spp.	#	#	#		#	#		
Order Trichoptera								
Ecnomidae		#					#	
Hydropsychidae								
Aethaloptera spp.		#			#		#	#
Amphipsyche spp.		#						#
Cheumatopsyche spp.		#	#	#	#	#	#	#

Table 4 cont. **Complete Taxa list for Kongola Bridge – All habitats combined**

Checklist of macro-invertebrates found at this site (families and *genus* listed alphabetically)	Sample dates							
	10/2/97	27/5/97	24/7/97	1/10/97	5/12/97	3/2/98	1/4/98	2/6/98
Leptoceridae								
Oecetis spp.		#		#		#	#	
Parasetodes spp.				#				
Trichosetodes spp.					#			
Philopotamidae (indet.)	#	#	#	#	#	#	#	#
Order Odonata								
Suborder Anisoptera								
Gomphidae (indet.)	#		#		#	#	#	#
Paragomphus spp.		#						
Libellulidae (indet.)	#			#	#		#	#
Trithemis spp.		#		#		#		
Suborder Zygoptera								
Coenagriidae								
Pseudagrion spp.	#	#	#	#	#	#	#	#
Order Diptera								
Chironomidae	#	#	#	#		#	#	#
Culicidae	#							
Simuliidae		#		#		#		
Tabanidae		#	#				#	#
Order Coleoptera								
Dytiscidae (indet.)					#			
Hyphydrus spp.			#				#	
Elmidae/Dryopidae		#			#	#		
Gyrinidae								
Orectochilus spp.	#			#	#	#	#	#
Hydrophilidae		#						
Hydrous spp.		#						
Noteridae								
Canthydrus spp.				#				
Order Hemiptera								
Gerridae (indet.)			#					
Naucoridae (indet.)		#						
Nepidae (indet.)	#			#	#			
Veliidae (indet.)	#	#	#	#				
Order Lepidoptera								
Pyralidae		#						

APPENDIX IV

Table 1 Taxa List for Lyadura – Marginal Vegetation habitat

Checklist of macro-invertebrates found at this site (families and *genus* listed alphabetically)	Sample dates								
	11/2/97	25/3/97	28/5/97	24/7/97	2/10/97	5/12/97	3/2/98	1/4/98	2/6/98
PHYLUM ANNELIDA									
Class Oligochaeta								#	
PHYLUM PLATYHELMINTHES									
Class Hirudinea									
Glossiphoniidae	#								
PHYLUM MOLLUSCA									
Class Gastropoda									
Ancylidae									
Ferrissia spp.				#					
Hydrobiidae									
Lobogenes michaelis				#					
Lymnaeidae (indet.)	#		#						
Physidae (indet.)									
Planorbidae (indet.)	#							#	#
Bulinus spp.					#				
Thiaridae (indet.)	#								
Class Bivalvia									
Corbiculidae									
Corbicula fluminalis				#	#				
Unionidae (indet.)								#	#
PHYLUM ARTHROPODA									
Class Crustacea									
Order Decapoda									
Atyidae									
Caradina africana					#				
Caradina nilotica	#		#	#	#		#	#	#
Class Insecta									
Order Ephemeroptera									
Baetidae									
Baetis spp.				#	#				
Centroptilum spp.							#		
Cloeon spp.	#			#	#			#	#
Demoulinia spp.					#				
Caenidae (indet.)									#
Afrocaenis spp.			#	#	#				
Caenodes spp.				#					
Order Trichoptera									
Leptoceridae									
Oecetis spp.				#					
Parasetodes spp.					#				
Order Odonata									
Suborder Anisoptera									
Aeshnidae (indet.)			#				#	#	#
Gomphidae (indet.)					#				
Libellulidae (indet.)	#							#	#
Trithemis spp.				#			#		
Suborder Zygoptera									
Coenagriidae									
Pseudagrion spp.	#		#	#	#		#	#	#

Table 1 cont. Taxa list for Lyadura – Marginal Vegetation habitat

Checklist of macro-invertebrates found at this site (families and *genus* listed alphabetically)	Sample dates								
	11/2/97	25/3/97	28/5/97	24/7/97	2/10/97	5/12/97	3/2/98	1/4/98	2/6/98
Order Diptera									
Chironomidae			#	#					#
Ceratapogonidae									
Order Coleoptera									
Curculionidae									
Dytiscidae (indet.)							#	#	
Hyphydrus spp.					#				
Laccophilus spp.			#		#				
Gyrinidae									
Orectochilus spp.				#					
Hydrophilidae (indet.)									
Enochrus spp.									
Hydrous spp.			#						
Helochares spp.			#						
Regimbartia spp.									
Noteridae									
Canthydrus spp.				#					
Order Hemiptera									
Corixidae								#	
Gerridae (indet.)	#								#
Naucoridae (indet.)			#					#	
Notonectidae (indet.)				#					
Nepidae					#		#		#
Veliidae	#								
Order Lepidoptera									
Pyralidae			#					#	#

Table 2 Taxa list for Lyadura – Aquatic Vegetation habitat

Checklist of macro-invertebrates found at this site (families and *genus* listed alphabetically)	Sample dates								
	11/2/97	25/3/97	28/5/97	24/7/97	2/10/97	5/12/97	3/2/98	1/4/98	2/6/98
PHYLUM ANNELIDA									
Class Oligochaeta								#	
PHYLUM PLATYHELMINTHES									
Class Hirudinea									
Glossiphoniidae	#	#							
PHYLUM MOLLUSCA									
Class Gastropoda									
Ampullariidae									
Lanistes ovum							#		
Ancylidae									
Ferrissia spp.						#			
Lymnaeidae (indet.)	#	#							
Thiaridae (indet.)									
Cleopatra spp.		#					#		
Melanoides tuberculata							#	#	
Planorbidae (indet.)	#								#
Bulinus spp.				#		#	#		
Gyraulus costulatus					#		#		
Physidae (indet.)		#							
Class Bivalvia									
Corbiculidae									
Corbicula fluminalis	#	#			#	#			
Unionidae (indet.)		#						#	#
PHYLUM ARTHROPODA									
Class Crustacea									
Order Decapoda									
Potamonautidae									
Potamonautes bayonianus								#	
Atyidae									
Caradina nilotica	#	#	#	#	#	#		#	#
Order Hydracarina									
Hydrachnellidae	#								
Class Insecta									
Order Ephemeroptera									
Baetidae									
Baetis spp.					#	#			
Centroptilum spp.							#		
Cloeon spp.	#	#		#	#	#		#	#
Demoulinia spp.									
Caenidae (indet.)		#				#		#	#
Afrocaenis spp.					#				
Caenodes spp.				#					
Polymitarcidae									
Povilla spp.		#						#	
Order Trichoptera									
Leptoceridae	#								
Parasetodes spp.						#			
Order Odonata									
Suborder Anisoptera									
Aeshnidae (indet.)								#	#
Hemianax spp.				#					
Gomphidae (indet.)				#					
Neurogomphus spp.						#			

Table 2 cont. Taxa list for Lyadura – Aquatic Vegetation habitat

Checklist of macro-invertebrates found at this site (families and *genus* listed alphabetically)	Sample dates								
	11/2 97	25 3 97	28 5 97	24/7/97	2/10/97	5/12/97	3/2/98	1/4/98	2/6/98
Libellulidae (indet.)		#						#	#
Trithemis spp.							#		
Suborder Zygoptera									
Coenagriidae									
Pseudagrion spp.	#	#	#	#	#	#	#	#	#
Order Diptera									
Ceratapogonidae	#	#							
Chironomidae	#	#	#		#			#	#
Order Coleoptera									
Curculionidae		#							
Dytiscidae (indet.)	#	#					#		
Hyphydrus spp.								#	
Laccophilus spp.				#		#		#	
Hydrophilidae (indet.)		#		#				#	
Enochrus spp.						#			
Regimbartia spp.						#			
Noteridae									
Canthydrus spp.				#					
Order Hemiptera									
Corixidae							#		
Gerridae (indet.)		#						#	
Naucoridae (indet.)		#	#	#		#	#	#	
Nepidae (indet.)				#		#			
Notonectidae (indet.)	#		#			#		#	
Veliidae	#								#
Order Lepidoptera									
Pyralidae		#		#					#

Table 3 Taxa list for Lyadura – Silt habitat

Checklist of macro-invertebrates found at this site (families and *genus* listed alphabetically)	Sample dates								
	11/2 97	25 3 97	28 5/97	24/7/97	2/10/97	5/12/97	3/2/98	1/4/98	2/6/98
PHYLUM MOLLUSCA									
Class Gastropoda									
Hydrobiidae									
Lobogenes michaelis			#						
Thiaridae									
Melanoides tuberculata			#	#					
Class Bivalvia									
Corbiculidae									
Corbicula fluminalis			#	#					
PHYLUM ARTHROPODA									
Class Insecta									
Order Diptera									
Chironomidae			#	#					

Table 4 Complete Taxa list for Lyadura – All habitats combined

Checklist of macro-invertebrates found at this site (families and *genus* listed alphabetically)	Sample dates								
	11/2/97	25/3/97	28/5/97	24/7/97	2/10/97	5/12/97	3/2/98	1/4/98	2/6/98
PHYLUM ANNELIDA									
Class Oligochaeta								#	
PHYLUM PLATYHELMINTHES									
Class Hirudinea									
Glossiphoniidae	#	#							
PHYLUM MOLLUSCA									
Class Gastropoda									
Ampullariidae									
Lanistes ovum							#		
Ancylidae									
Ferrissia spp.				#		#			
Hydrobiidae									
Lobogenes michaelis			#	#					
Lymnaeidae (indet.)	#	#	#						
Planorbidae (indet.)	#								#
Bulinus spp.				#	#	#	#	#	
Gyraulus costulatus					#		#		
Physidae (indet.)		#							
Thiaridae (indet.)									
Cleopatra spp.		#					#		
Melanoides tuberculata	#		#	#			#	#	
Class Bivalvia									
Corbiculidae									
Corbicula fluminalis	#	#	#	#	#	#			
Unionidae (indet.)		#						#	#
PHYLUM ARTHROPODA									
Class Crustacea									
Order Decapoda									
Potamonautidae									
Potamonautes bayonianus								#	
Atyidae									
Caradina africana					#				
Caradina nilotica	#	#	#	#	#	#	#	#	#
Order Hydracarina									
Hydrachnellidae	#								
Class Insecta									
Order Ephemeroptera									
Baetidae									
Baetis spp.				#	#	#			
Centroptilum spp.							#		
Cloeon spp.	#	#		#	#	#		#	#
Demoulinia spp.					#				
Caenidae (indet.)		#	#			#		#	#
Afrocaenis spp.				#	#				
Caenodes spp.				#					
Polymitarcidae									
Povilla spp.		#						#	
Order Trichoptera									
Leptoceridae	#								
Oecetis spp.				#					
Parasetodes spp.					#	#			

Table 4 cont. Complete Taxa list for Lyadura – All habitats combined

Checklist of macro-invertebrates found at this site (families and *genus* listed alphabetically)	Sample dates								
	11/2/97	25/3/97	28/5/97	24/7/97	2/10/97	5/12/97	3/2/98	1/4/98	2/6/98
Order Odonata									
Suborder Anisoptera									
Aeshnidae (indet.)			#				#	#	#
Hemianax spp.				#					
Gomphidae (indet.)				#	#				
Neurogomphus spp.						#			
Libellulidae (indet.)	#	#						#	#
Trithemis spp.				#			#		
Suborder Zygoptera									
Coenagriidae									
Pseudagrion spp.	#	#	#	#	#	#	#	#	#
Order Diptera									
Ceratapogonidae	#	#							
Chironomidae	#	#	#	#	#			#	#
Culicidae			#						
Order Coleoptera									
Curculionidae		#							
Dytiscidae (indet.)	#	#					#		
Hyphydrus spp.					#			#	
Laccophilus spp.			#	#	#	#		#	
Gyrinidae									
Orectochilus spp.				#					
Hydrophilidae (indet.)		#		#				#	
Enochrus spp.						#			
Helochares spp.			#						
Hydrous spp.			#						
Regimbartia spp.						#			
Noteridae									
Canthydrus spp.				#					
Order Hemiptera									
Corixidae							#	#	
Gerridae (indet.)	#	#						#	#
Naucoridae (indet.)		#	#	#		#	#	#	
Nepidae (indet.)				#	#	#	#		#
Notonectidae (indet.)	#		#	#		#		#	
Veliidae	#								#
Order Lepidoptera									
Pyralidae		#	#	#					#

APPENDIX V

Table 1 Complete Taxa list for Ngoma Bridge for the only habitat – Marginal Vegetation

Checklist of macro-invertebrates found at this site (families and *genus* listed alphabetically)	Sample dates 29/5/97	23/7/97	30/9/97	3/12/97	4/2/98	30/3/98	3/6/98
PHYLUM ANNELIDA							
Class Oligochaeta		#					
PHYLUM PLATYHELMINTHES							
Class Hirudinea							
Glossiphoniidae					#		
PHYLUM MOLLUSCA							
Class Gastropoda							
Ampullariidae							
Lanistes ovum				#			
Pila occidentalis			#				
Lymnaeidae							
Lymnaea spp.		#		#	#		
Planorbidae							
Bulinus spp.		#	#	#			
Gyraulus costulatus					#		
Lentorbis spp.			#				
PHYLUM ARTHROPODA							
Class Crustacea							
Order Decapoda							
Atyidae							
Caradina nilotica			#	#	#		
Class Insecta							
Order Ephemeroptera							
Baetidae							
Centroptilum spp.						#	
Cloeon spp.	#	#		#	#	#	#
Caenidae (indet.)			#	#			
Afrocaenis spp.					#		
Polymitarcidae							
Povilla spp.					#		
Order Trichoptera							
Ecnomidae					#		
Order Odonata							
Suborder Anisoptera							
Aeshnidae (indet.)	#	#		#			
Libellulidae (indet.)		#		#			#
Sympetrum spp.			#				
Trithemis spp.					#		
Suborder Zygoptera							
Coenagriidae							
Enallagma spp.	#				#		
Pseudagrion spp.		#	#	#	#		
Order Diptera							
Ceratapogonidae				#			
Chironomidae	#	#	#			#	
Tabanidae		#	#	#			
Order Coleoptera							
Curculionidae	#						
Dytiscidae							
Darwinhydrus spp.		#					

Table 1 cont. Complete Taxa list for Ngoma Bridge for the only habitat – Marginal Vegetation

Checklist of macro-invertebrates found at this site (families and *genus* listed alphabetically)	Sample dates						
	29/5/97	23/7/97	30/9/97	3/12/97	4/2/98	30/3/98	3/6/98
Hydrophilidae (indet.)				#		#	
Enochrus spp.				#			
Hydrophilus spp.	#						
Order Hemiptera							
Corixidae (indet.)						#	
Gerridae (indet.)	#	#		#			
Naucoridae (indet.)	#		#	#			
Nepidae (indet.)			#	#			
Notonectidae (indet.)	#	#		#		#	
Veliidae		#					

APPENDIX VI

Table 1 Complete Taxa list for Ihaha for the only habitat – Marginal Vegetation

Checklist of macro-invertebrates found at this site (families and genus listed alphabetically)	Sample dates						
	29/5/97	23/7/97	30/9/97	3/12/97	4/2/98	30/3/98	3/6/98
PHYLUM MOLLUSCA							
Class Gastropoda							
Ancylidae							
Ferrissia spp.		#					
Bithyniidae							
Gabbiella kisalensis					#		
Hydrobiidae							
Lobogenes michaelis		#					
Lymnaeidae							
Lymnaea spp.			#				
Planorbidae							
Bulinus spp.	#	#	#		#		
Gyraulus costulatus		#			#		
Lentorbis spp.		#					
Class Bivalvia							
Corbiculidae							
Corbicula fluminalis		#					
Sphaeriidae							
Eupera ferruginea					#		
PHYLUM ARTHROPODA							
Class Crustacea							
Order Decapoda							
Atyidae							
Caradina nilotica		#	#	#	#		
Order Ephemeroptera							
Baetidae							
Centroptilum spp.	#						
Cloeon spp.	#	#	#	#	#		
Caenidae (indet.)				#	#		
Afrocaenis spp.					#		
Caenis spp.		#					
Polymitarcidae							
Povilla spp.			#		#		
Order Trichoptera							
Ecnomidae			#	#	#		
Order Odonata							
Suborder Anisoptera							
Aeshnidae (indet.)							
Anax spp.	#						
Libellulidae (indet.)		#	#	#			
Palpopleura spp.	#	#					
Sympetrum spp.	#						
Trithemis spp.	#				#		
Suborder Zygoptera							
Coenagriidae							
Ceriagrion spp.			#				
Ischnura / Enallagma	#	#	#				
Pseudagrion spp.		#	#	#	#		

Table 1 cont. Complete Taxa list for Ihaha for the only habitat – Marginal Vegetation

Checklist of macro-invertebrates found at this site (families and *genus* listed alphabetically)	Sample dates						
	29/5/97	23/7/97	30/9/97	3/12/97	4/2/98	30/3/98	3/6/98
Order Diptera							
Ceratapogonidae							
Chironomidae	#	#		#	#		
Culicidae		#			#		
Tabanidae							
Order Coleoptera							
Dytiscidae							
Gyrinidae							
Dineutus spp.	#	#					
Hydrophilidae (indet.)							
Enochrus spp.							
Helochares spp.		#					
Regimbartia spp.			#				
Noteridae							
Canthydrus spp.		#					
Order Hemiptera							
Corixidae (indet.)	#	#					
Gerridae (indet.)		#					
Naucoridae (indet.)	#	#	#				
Nepidae (indet.)			#				
Notonectidae (indet.)	#	#					
Veliidae							

APPENDIX VII

Table 1 Taxa list for Ichingo for the habitat – Aquatic Vegetation

Checklist of macro-invertebrates found at this site (families and *genus* listed alphabetically)	Sample dates						
	29/5/97	7/8/97	30/9/97	3/12/97	5/2/98	2/4/98	4/6/98
PHYLUM ANNELIDA							
Class Oligochaeta					#		
PHYLUM MOLLUSCA							
Class Gastropoda							
Thiaridae							
Cleopatra spp.					#	#	
Melanoides victoriae					#		
Viviparidae							
Bellamya capillata					#		
PHYLUM ARTHROPODA							
Class Crustacea							
Order Decapoda							
Potamonautidae							
Potamonautes bayonianus		#			#		
Atyidae							
Caradina africana		#					
Caradina nilotica		#				#	
Class Hydracarina							
Hydrachnellidae						#	
Class Insecta							
Order Ephemeroptera							
Baetidae							
Baetis spp.		#			#		
Demoulinia spp.					#	#	#
Caenidae (indet.)						#	#
Caenodes spp.		#					
Tricorythidae							
Tricorythus spp.		#					
Order Trichoptera							
Hydropsychidae							
Amphipsyche spp.					#		
Cheumatopsyche spp.					#		#
Order Odonata							
Suborder Anisoptera							
Gomphidae							
Paragomphus spp.		#					
Libellulidae (indet.)						#	
Suborder Zygoptera							
Coenagriidae							
Pseudagrion spp.		#			#		
Order Diptera							
Chironomidae		#				#	#
Simuliidae		#			#	#	#
Tabanidae						#	
Order Hemiptera							
Nepidae					#		
Hydroptilidae							#
Order Coleoptera							
Dytiscidae						#	

Table 2 Taxa list for Ichingo for the habitat – Stones in Current

Checklist of macro-invertebrates found at this site (families and *genus* listed alphabetically)	Sample dates 29/5/97	7/8/97	30/9/97	3/12/97	5/2/98	2/4/98	4/6/98
PHYLUM ANNELIDA							
Class Oligochaeta					#		
PHYLUM MOLLUSCA							
Class Gastropoda							
Thiaridae							
Melanoides victoriae					#		
Class Bivalvia							
Corbiculidae							
Corbicula fluminalis					#		
Unionidae							
Coelatura kunenensis					#		
PHYLUM ARTHROPODA							
Class Crustacea							
Order Decapoda							
Potamonautidae							
Potamonautes bayonianus		#					
Class Insecta							
Order Ephemeroptera							
Baetidae							
Centroptiloides spp.		#					
Demoulinia spp.							#
Pseudopannota spp.		#			#		#
Ophelmatostoma spp.		#					
Heptageniidae							
Afronurus spp.					#		
Leptophlebiidae							
Choroterpes spp.					#		
Oligoneuridae							
Elassoneuria spp.		#			#		
Prosopistomatidae							
Binoculus spp.					#		
Tricorythidae							
Tricorythus spp.		#			#		
Order Trichoptera							
Hydropsychidae							
Aethaloptera spp.					#		
Amphipsyche spp.		#					
Cheumatopsyche spp.		#			#		#
Macronema spp.		#			#		
Philopotamidae (indet.)					#		
Order Diptera							
Chironomidae							#
Simuliidae		#			#		
Order Neuroptera							
Sisyridae							#
Order Coleoptera							
Gyrinidae							
Orectochilus spp.					#		
Order Lepidoptera							
Pyralidae		#					

Table 3 Complete Taxa list for Ichingo – All habitats combined

Checklist of macro-invertebrates found at this site (families and *genus* listed alphabetically)	Sample dates						
	29/5/97	7/8/97	30/9/97	3/12/97	5/2/98	2/4/98	4/6/98
PHYLUM ANNELIDA							
Class Oligochaeta					#		
PHYLUM MOLLUSCA							
Class Gastropoda							
Thiaridae							
Cleopatra spp.					#	#	
Melanoides victoriae					#		
Viviparidae							
Bellamya capillata					#		
Class Bivalvia							
Corbiculidae							
Corbicula fluminalis							
Unionidae							
Coelatura kunenensis					#		
PHYLUM ARTHROPODA							
Class Crustacea							
Order Decapoda							
Potamonautidae							
Potamonautes bayonianus		#			#		
Atyidae							
Caradina africana		#					
Caradina nilotica		#				#	
Class Hydracarina							
Hydrachnellidae						#	
Class Insecta							
Order Ephemeroptera							
Baetidae							
Baetis spp.		#			#		
Centroptiloides spp.		#					
Demoulinia spp.					#	#	#
Pseudopannota spp.		#			#		#
Ophelmatostoma spp.		#					
Caenidae (indet.)						#	#
Caenodes spp.		#					
Heptageniidae							
Afronurus spp.					#		
Leptophlebiidae							
Choroterpes spp.					#		
Oligoneuridae							
Elassoneuria spp.		#			#		
Prosopistomatidae							
Binoculus spp.					#		
Tricorythidae							
Tricorythus spp.		#			#		
Order Trichoptera							
Hydropsychidae							
Aethaloptera spp.					#		
Amphipsyche spp.		#			#		
Cheumatopsyche spp.		#			#		#
Macronema spp.		#			#		
Philopotamidae (indet.)					#		

Table 3 cont. Complete Taxa list for Ichingo – All habitats combined

Checklist of macro-invertebrates found at this site (families and *genus* listed alphabetically)	Sample dates						
	29/5/97	7/8/97	30/9/97	3/12/97	5/2/98	2/4/98	4/6/98
Order Odonata							
Suborder Anisoptera							
Gomphidae							
Paragomphus spp.		#					
Libellulidae (indet.)						#	
Suborder Zygoptera							
Coenagriidae							
Pseudagrion spp.		#			#		
Order Diptera							
Chironomidae		#				#	#
Simuliidae		#			#	#	#
Tabanidae						#	
Order Coleoptera							
Dytiscidae					#		
Gyrinidae							
Orectochilus spp.					#		
Order Hemiptera							
Nepidae					#		
Hydroptilidae							#
Order Lepidoptera							
Pyralidae		#					

APPENDIX VIII

Table 1 Taxa list for Wenela for habitat – Stones in Current

Checklist of macro-invertebrates found at this site (families and *genus* listed alphabetically)	Sample dates							
	12/2/97	30/5/97	8/8/97	30/9/97	3/12/97	4/2/98	8/4/98	3/6/98
PHYLUM ANNELIDA								
Class Oligochaeta		#	#		#	#		#
Class Hirudinea								
Erpobdellidae				#	#			
PHYLUM MOLLUSCA								
Class Gastropoda								
Thiaridae								
Melanoides spp.				#		#		
Class Bivalvia								
Corbiculidae								
Corbicula fluminalis		#			#			
Unionidae (indet.)				#				#
PHYLUM ARTHROPODA								
Class Crustacea								
Order Decapoda								
Potamonautidae								
Potamonautes bayonianus				#	#	#		
Class Insecta								
Order Ephemeroptera								
Baetidae								
Afrobaetodes spp.		#						
Afroptilum spp.		#						
Baetis spp.		#	#	#	#	#		#
Centroptiloides spp.			#					
Demoulinia spp.		#						
Pseudopannota spp.		#	#					#
Ophelmatostoma spp.		#	#					#
Caenidae (indet.)					#	#		
Afrocaenis spp.			#	#				
Caenodes spp.			#					
Caenospella spp.				#				
Heptageniidae								
Afronurus spp.			#		#			
Leptophlebiidae								
Choroterpes spp.		#	#	#	#			#
Thraulus spp.				#				
Genus & species indet.				#				
Oligoneuridae								
Elassoneuria spp.		#	#	#	#	#		#
Polymitarcidae								
Exeuthyplocia spp.			#	#				
Prosopistomatidae								
Binoculus spp.			#	#	#			
Tricorythidae								
Tricorythus spp.		#	#	#	#	#		
Order Plecoptera								
Perlidae (indet.)			#	#	#			

Table 1 cont. Taxa list for Wenela for habitat – Stones in Current

Checklist of macro-invertebrates found at this site (families and *genus* listed alphabetically)	Sample dates							
	12/2/97	30/5/97	8/8/97	30/9/97	3/12/97	4/2/98	8/4/98	3/6/98
Order Trichoptera								
Ecnomidae				#	#	#		
Hydropsychidae								
Aethaloptera spp.		#		#				#
Amphipsyche spp.		#				#		#
Cheumatopsyche spp.		#	#	#	#	#		#
Macronema spp.		#		#	#			#
Polymorphanisus spp.		#		#				#
Leptoceridae								
Oecetis spp.		#				#		
Philopotamidae (indet.)		#		#		#		#
Order Odonata								
Suborder Anisoptera								
Gomphidae								
Paragomphus spp.		#						
Libellulidae (indet.)								#
Order Diptera								
Chironomidae		#		#	#	#		#
Simuliidae					#	#		
Tabanidae		#		#				
Order Coleoptera								
Elmidae / Dryopidae			#					#
Gyrinidae								
Orectochilus spp.		#		#				

Table 2 Taxa list for Wenela for habitat – Marginal vegetation

Checklist of macro-invertebrates found at this site (families and *genus* listed alphabetically)	Sample dates							
	12/2/97	30/5/97	8/8/97	30/9/97	3/12/97	4/2/98	8/4/98	3/6/98
PHYLUM ANNELIDA								
Class Oligochaeta	#	#						
PHYLUM MOLLUSCA								
Class Gastropoda								
Ancylidae								
Ferrissia spp.					#			
Planorbidae								
Gyraulus costulatus					#			
Thiaridae								
Cleopatra spp.		#	#					
Melanoides victoriae						#		
Class Bivalvia								
Corbiculidae								
Corbicula fluminalis	#				#			
Unionidae (indet.)				#				
PHYLUM ARTHROPODA								
Class Crustacea								
Order Decapoda								
Potamonautidae								
Potamonautes bayonianus			#	#				
Atyidae								
Caradina africana		#						
Caradina nilotica			#					
Class Insecta								
Order Ephemeroptera								
Baetidae								
Baetis spp.	#	#	#	#	#	#	#	#
Cloeon spp.				#		#	#	
Ophelmatostoma spp.		#						
Caenidae (indet.)						#	#	#
Afrocaenis spp.				#	#			
Caenodes spp.		#	#					
Heptageniidae								
Afronurus spp.	#		#	#	#			#
Leptophlebiidae								
Choroterpes spp.	#							
Oligoneuridae								
Elassoneuria spp.	#	#						
Tricorythidae								
Tricorythus spp.		#						
Order Trichoptera								
Ecnomidae					#		#	
Hydropsychidae								
Amphipsyche spp.	#	#						
Cheumatopsyche spp.	#	#				#		
Leptoceridae								
Oecetis spp.		#						
Philopotamidae (indet.)		#						
Order Odonata								
Suborder Anisoptera								
Gomphidae (indet.)								#
Lestinogomphus spp.				#				
Libellulidae (indet.)	#			#	#	#	#	

Table 2 cont. Taxa list for Wenela for habitat – Marginal vegetation

Checklist of macro-invertebrates found at this site (families and *genus* listed alphabetically)	Sample dates							
	12/2/97	30/5/97	8/8/97	30/9/97	3/12/97	4/2/98	8/4/98	3/6/98
Suborder Zygoptera								
Coenagriidae								
Ischnura spp.					#			
Pseudagrion spp.	#		#	#	#	#	#	
Order Diptera								
Ceratapogonidae	#	#	#					
Chironomidae	#	#	#		#		#	#
Simuliidae	#	#						
Order Coleoptera								
Gyrinidae								
Orectochilus spp.		#						
Hydrophilidae								
Helochares spp.				#				
Noteridae								
Canthydrus spp.				#	#			
Order Hemiptera								
Naucoridae	#	#			#			
Veliidae	#		#					

Table 3 Complete Taxa list for Wenela – All habitats combined

Checklist of macro-invertebrates found at this site (families and *genus* listed alphabetically)	Sample dates							
	12/2/97	30/5/97	8/8/97	30/9/97	3/12/97	4/2/98	8/4/98	3/6/98
PHYLUM ANNELIDA								
Class Oligochaeta	#	#	#		#	#		#
Class Hirudinea								
Erpobdellidae				#	#			
PHYLUM MOLLUSCA								
Class Gastropoda								
Ancylidae								
Ferrissia spp.					#			
Planorbidae								
Gyraulus costulatus					#			
Thiaridae								
Cleopatra spp.		#	#					
Melanoides victoriae				#		#		
Class Bivalvia								
Corbiculidae								
Corbicula fluminalis	#	#			#			
Unionidae (indet.)				#				#
PHYLUM ARTHROPODA								
Class Crustacea								
Order Decapoda								
Potamonautidae								
Potamonautes bayonianus			#	#	#	#		
Atyidae								
Caradina africana		#						
Caradina nilotica			#					
Class Insecta								
Order Ephemeroptera								
Baetidae								
Afrobaetodes spp.		#						
Afroptilum spp.		#						
Baetis spp.	#	#	#	#	#	#	#	#
Centroptiloides spp.			#					
Cloeon spp.				#		#	#	
Demoulinia spp.		#						#
Ophelmatostoma spp.		#	#					
Pseudopannota spp.		#	#					#
Caenidae (indet.)					#	#	#	#
Afrocaenis spp.			#	#	#			
Caenodes spp.		#	#					
Caenospella spp.				#				
Heptageniidae								
Afronurus spp.	#		#	#	#			#
Leptophlebiidae								
Choroterpes spp.	#	#	#	#	#			
Genus & species indet.				#	#			#
Thraulus spp.				#				
Oligoneuridae								
Elassoneuria spp.	#	#	#	#	#	#		
Polymitarcidae								
Exeuthyplocia spp.			#	#	#			
Prosopistomatidae								
Binoculus spp.			#	#	#			
Tricorythidae								
Tricorythus spp.		#	#	#	#	#		

Table 3 Complete Taxa list for Wenela – All habitats combined

Checklist of macro-invertebrates found at this site (families and *genus* listed alphabetically)	Sample dates 12/2/97	30/5/97	8/8/97	30/9/97	3/12/97	4/2/98	8/4/98	3/6/98
Order Plecoptera								
Perlidae			#	#	#			
Order Trichoptera								
Ecnomidae				#	#	#	#	
Hydropsychidae								
Aethaloptera spp.		#		#				
Amphipsyche spp.	#	#				#		#
Cheumatopsyche spp.	#	#	#	#	#	#		#
Macronema spp.		#		#	#			#
Polymorphanisus spp.		#		#				
Leptoceridae								
Oecetis spp.		#				#		
Philopotamidae (indet.)		#		#	#	#		#
Order Odonata								
Suborder Anisoptera								
Gomphidae (indet.)								#
Lestinogomphus spp.				#				
Paragomphus spp.		#						
Libellulidae (indet.)	#			#	#	#	#	#
Suborder Zygoptera								
Coenagriidae								
Ischnura spp.					#			
Pseudagrion spp.	#		#	#	#	#	#	
Order Diptera								
Ceratapogonidae	#	#	#					
Chironomidae	#	#	#	#	#	#	#	#
Simuliidae	#	#			#	#		
Tabanidae		#		#				
Order Coleoptera								
Elmidae / Gyrinidae			#					#
Gyrinidae								
Orectochilus spp.		#		#				
Hydrophilidae								
Helochares spp.				#				
Noteridae								
Canthydrus spp.				#	#			
Order Hemiptera								
Naucoridae	#	#			#			
Veliidae	#		#					