Internal Report

An exploratory survey and synthesis of previous surveys conducted along the Tugela (Thukela) and Bushmans Rivers to advise on instream flow requirements of the aquatic macroinvertebrates.

by

F C de Moor, H M Barber-James and C R Lugo-Ortiz

Department of Freshwater Invertebrates
Albany Museum
Somerset Street
Grahamstown 6139

Report without Figures 1 – 7

October 1999

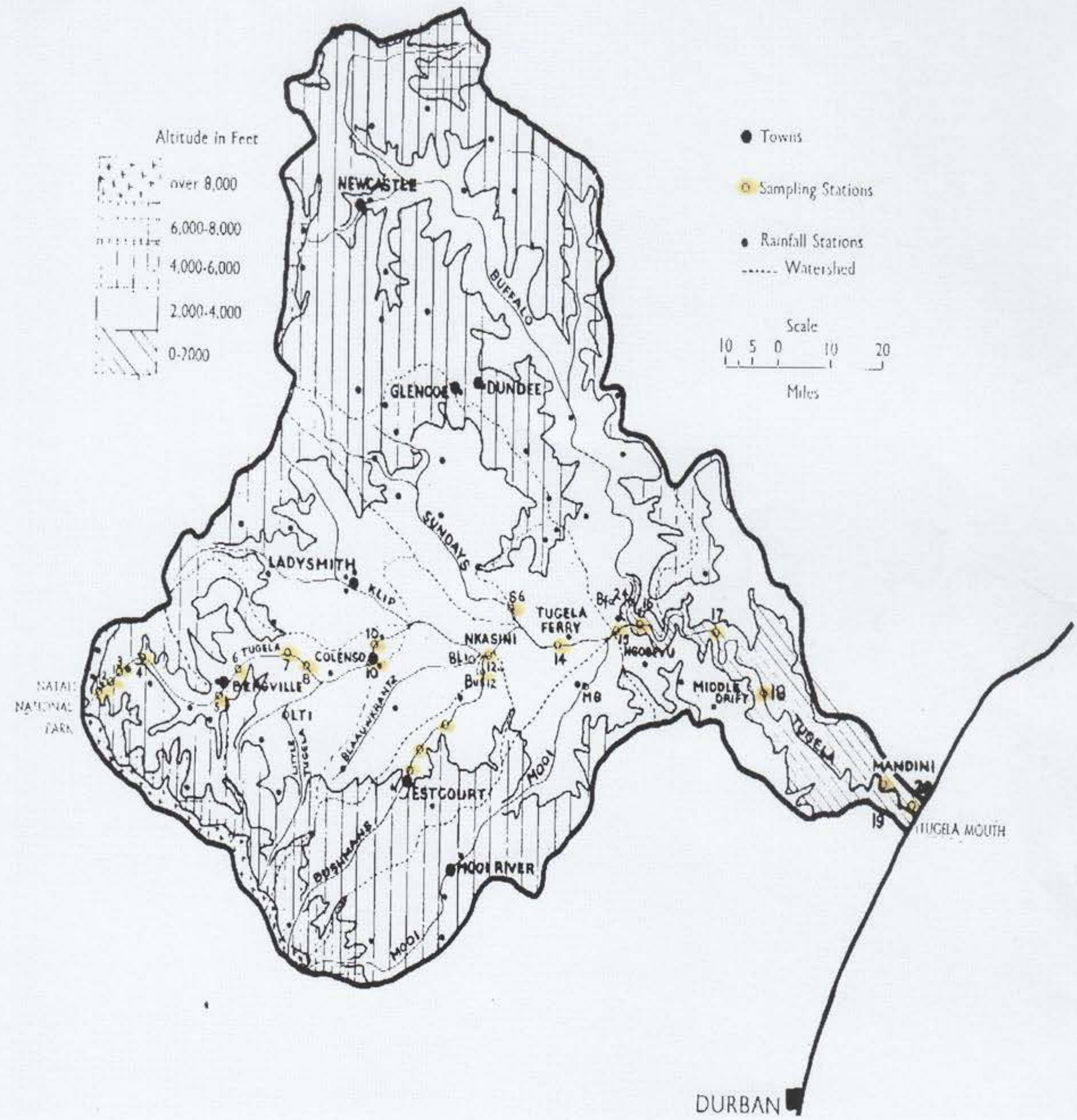

Figure 1: Sampling stations surveyed during the 1953-1955 survey of the Tugela River Catchment from Oliff 1960a

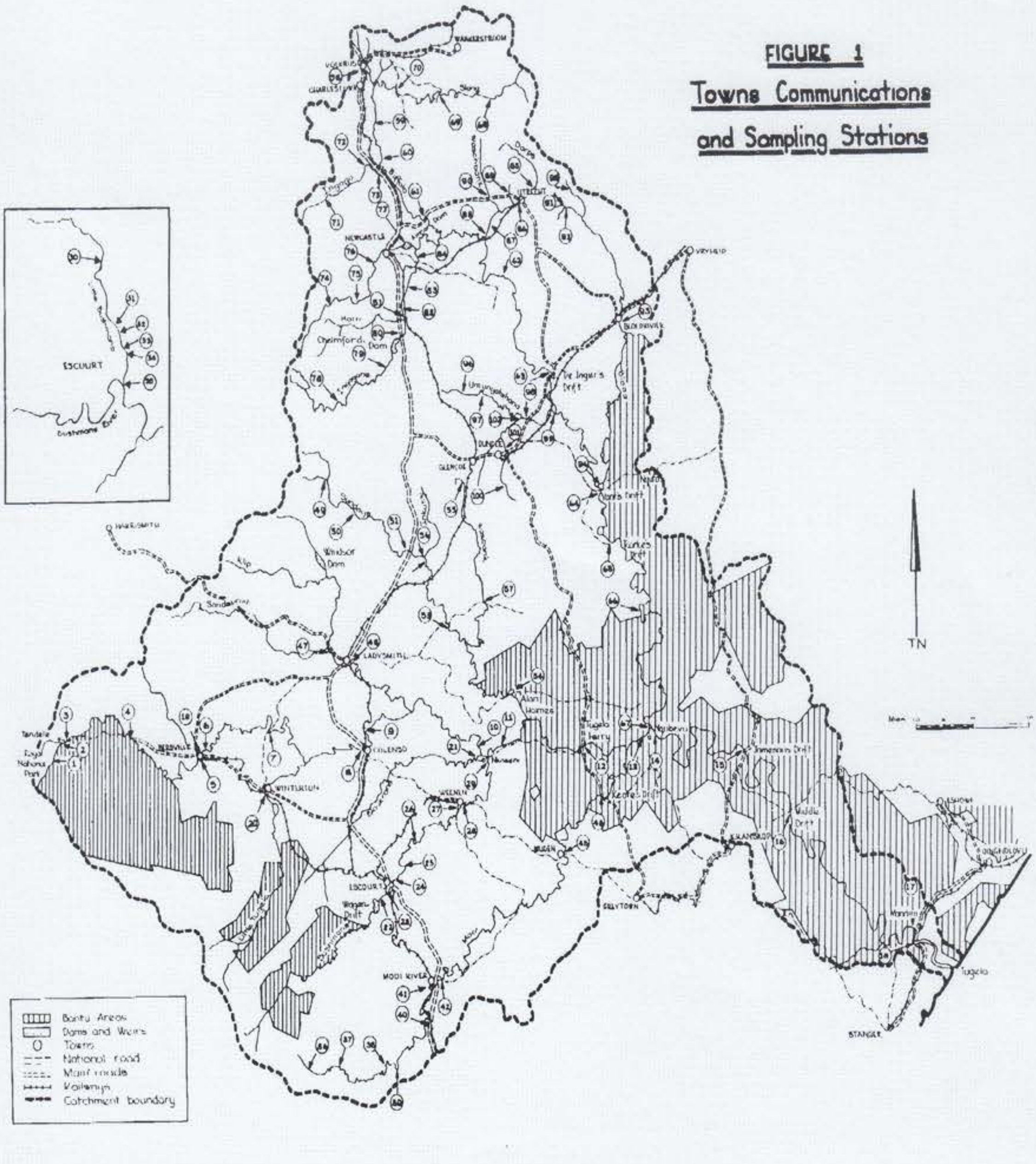

Figure 2: Sampling stations surveyed for the Town and Regional Planning regional survey (Brand *et al* 1967)

Internal Report

An exploratory survey and synthesis of previous surveys conducted along the Tugela (Thukela) and Bushmans Rivers to advise on instream flow requirements of the aquatic macroinvertebrates.

by

F C de Moor, H M Barber-James and C R Lugo-Ortiz

Department of Freshwater Invertebrates
Albany Museum
Somerset Street
Grahamstown 6139

October 1999

EXECUTIVE SUMMARY AND CONCLUSIONS

The Department of Water Affairs are planning further interbasin transfers of water from the Tugela and Bushmans Rivers to supplement the evergrowing demand for water in Gauteng. Before planning of an interbasin tranfer of water it is important to consider sociopolitical and biological factors that may be detrimentally effected. The biological integrity of a river system must be cared for and an increase or decrease in flow can have deleterious influences on the riverine biota and impinge on the natural ecological functioning of the river. From a biological viewpoint it is important to consider whether there may be any transfer of undesirable biota from one catchment to another. Also will the modified flow regime lead to an increase in pest species in either the donor or recipient river system? Will any rare or endangered species be threatened by a modified regulated flow regime?

Between 1953 and 1955 Dr W D Oliff surveyed the Tugela (Thukela) River and between 1956 and 1957 the Bushmans River (Oliff 1960a, 1960b). Brand et al (1967) conducted further surveys in 1965 and produced a synthesis on previous surveys. In 1984 and 1985 Mr B K Fowles resurveyed many of the sites studied during the 1950's and 1960's in order to obtain some measure of changes that might have occurred in the intervening 30 year period. Unfortunately there was insufficient funding to analyse and report on all the rivers surveyed and only a preliminary assessment of selected samples from the Buffalo River was conducted (Fowles 1986). All these papers and reports analysed the status and abundance of the aquatic macroinvertebrates relating primarily to water quality.

An assessment of the instream flow requirements IFR of the macroinvertebrates of the Tugela River at selected sites was reported on by Chutter in Heinsohn (1995). In this report a number of indirect impacts on macroinvertebrates resulting from flow regulation by means of dams were listed. The importance of maintaining permanent flow and ensuring correct seasonal distribution of high and low flow regimes was emphasised. The shortage of detailed information on the flow requirements of most freswater biota was noted. It was therfore suggested that the modified flow regime should be managed in order to maintain existing biotope diversity. This could of course be reflected by measuring the diversity of selected aquatic macroinvertebrates especially species with narrow or stenoptopic requirements. From this viewpoint the assessment of species presently found and an assessment of overal species diversity, being assessed in this study, will serve to provide a baseline measure of what is there and what needs to have special care to be conserved. Because of previous surveys it was possible to assess, to a degree, what changes had occurred in these river system since the 1950's. Only a monitoring system able to assess the continued presence of selected species over the long-term can help prevent flow regulation practices detrimental to species earmarked for conservation.

In August 1999 a helicopter survey and a visit to some sites by motorvehicle enabled preliminary assessment of the diversity of aquatic biotopes along the Tugela and the Bushmans rivers, downstream of the proposed Jana and Mielietuin dam sites. Some collection of macroinvertebrates from selected biotopes along the Bushmans and Tugela Rivers was also undertaken. A one-week follow up survey in early October conducted further collections and although the samples collected could not be fully analysed, identification of selected material was carried out.

During the second survey sites which were considered important for determining the species composition under prevailing flows and for assessing flow requirements of the instream biota were selected for further survey purposes and study. SASS collecting techniques were used with the following modification; as many biotopes as possible were sampled at each site, a fine mesh size net (280 micrometre pore size) was used at most sites and material collected from each biotope was preserved separately. In addition to the SASS methods, other specialised collecting techniques to sample as wide a diversity of macroinvertebrates as possible were also used.

The brief given for this project was to assess changes in species diversity that might occur following construction of dams upstream. Information on the flow requirements needed to maintain the present diversity of biota in the donor river systems were also considered. In order to assess the flow requirements of these rivers it is considered important to determine the water quality and quantity requirements of the biota. As previous surveys were conducted around 45 and 15 years ago it was deemed necessary to determine changes that may have occurred in the present river systems. A resurvey of selected sites and a study of the previous surveys conducted along the Tugela and Bushmans Rivers was made. All this information was synthesised to determine if there were any rare or endangered species or possibly species with special environmental requirements that should be taken into account. Ideally river flows should be managed to ensure the survival of the extant communities along the river. If this is done, good quality water for downstream users (biota and man) can be ensured.

Because of the time limitations for conducting the study (approximately two months from the inception of the project) a detailed survey of the riverine biota was not possible. Complete analysis of the limited data collected was also not feasible and the level of identification of many of the invertebrate groups could not be carried down to species level. Data on the 1999 survey were collected during extreme low-flows and would therefore not reflect the greatest annual diversity of the river systems studied.

Even with the limited data available it was possible to note that no further serious deterioration of water quality has occurred in the lower reaches of the Bushmans River since the 1960's. A rich diversity of hydropneustic aquatic insects in both the Tugela and Bushmans Rivers suggested that the water was of a relatively good quality especialy at the lowermost site in the Bushmans River.

Regarding species composition of known taxa, the fauna has not changed markedly over a 45 year period. Ephemeroptera and Trichoptera are still diverse and dominant taxonomic groups. The early surveys showed clearly that the upper reaches of the Tugela River identified as the mountain and foothill torrent zones in Oliff's 1960a paper had a distinctive fauna. The present survey did not take these regions into account and discussion of the unique fauna are left only as a mention in tables 4-8.

Impacts on the river ecology resulting from the construction of the impoundments are:

* The downstream zonation of aquatic macroinvertebrates observed in the Tugela River will

be disrupted and will be influenced with changes in species and the relative abundance of various species occurring.

* Colder water discharged from the bottom of the dams at regular intervals will have a devastating effect on the macroinvertebrate biota. Natural seasonal water temperatures will be disrupted. Irregular temperature fluctuations will upset the biological rhythms of many species and aquatic insects will fail to pupate, metamorphose or emerge. Certain adaptable species will become abundant and become pests which will be costly to control.

* Bottom releases of anoxic water will be toxic to riverine biota.

* Reduced sediment loads in swift flowing water immediately downstream of the dam will lead to increased erosion capacity and this will lead to exposure of bedrock (armouring) in these reaches. Species community structure will be disrupted with no detritus for detrital feeding species. Such conditions will favour bedrock dwelling species i.e. certain species of Simuliidae and hydropsychid Trichoptera.

* The Tugela and Bushmans Rivers have a mixture of suspension filter feeders and detritus feeders with low numbers of grazers. Reduced input of detritus and particulate matter in the river downstream of the dam sites will influence macroinvertebrate community structure. Subtle changes in species dominance and a gradual change in the functional ecological role of species will occur.

* Less sediment in the water will lead to a greater clarity of water with more algal and plant growth on substrates downstream of the impoundments. Greater clarity of the water will make species more vulnerable to predators dependant on vision. This will lead to subtle changes in species composition.

* Clear water in dams could enhance algal blooms. Phyto and zooplankton will increase and be released into the river downstream. This will favour filter feeding simuliids and hydropsychids.

* Much further downstream of the Dams lower flows will lead to increased sedimenting up of riffles and a loss of braided sections of river. This will lead to a reduction in the heterogeneity of substrata and reduction in species diversity. This will modify the river ecology leaving fewer but dominant species which will periodically develop into pest proportional population sizes.

RECOMMENDATIONS

* Ecological requirements of the biota are strongly governed by the flow and thermal regime of the river and modification of sediment deposition or erosion and seasonally unaturally low or high temperatures as well as rapid fluctuations in temperature will lead to species eradication and functional community structural changes.

* To assess in greater detail whether there are rare or endangered species as well as concentrations of potential problem or pest species along the course of the rivers, a two year

in-depth survey of the benthic macroinvertebrates in the late winter and late summer as well as light trap and adult insect collecting in summer should be undertaken.

* As a management proposal for the Tugela River it is recommended that efforts should be made, at least to maintain and if possible try to improve conditions that will enhance the diversity of filter feeding species in the riffle and running water biotopes.

* The regulated flow regime should be simulated to model as closely as possible the natural seasonal flow regime. Unseasonal releases of water should be prevented at all times.

* Maintenance of sediment free substrata and prevention of clogging of interstices in riffles should be managed.

* The lower sandbed reaches in zone 7 have braided channels with riffles, cascades and rapids as well as islands of macrophytes. These biotopes should be accounted for in designing a flow regime. The maintenance of a diversity of biotopes in these lower sandbed reaches will ensure that no single group of animals will dominate the fauna of the river. Maintenance of species diversity will ensure that pest species such as certain *Simulium* spp. and bilharzia vector snails do not become abundant, a problem which would have to be further managed.

* The presence of a mixed community of filter-feeding and gatherer-collector species characterised the Tugela and Bushmans Rivers for all sites surveyed. There are many species that require a regular input of detritus and sediment for continued survival. Careful management of the thermal regime should also be considered in the river management programme.

A regular monitoring programme should be developed to ensure that the recommendations are met. A late winter/dry season survey of benthic macroinvertebrates should be undertaken annually. In addition, a late summer survey with light traps (to collect adults) should be implemented. The monitoring programme should cover the following:

* An in-depth two year survey to develop a base-line data set for determining the species diversity and relative abundance of key taxa
* Annual monitoring of species diversity
* Annual determination of the relative abundance of selected species

SUMMARY

Between 1953 and 1955 Dr W D Oliff surveyed the Tugela (Thukela) River and between 1956 and 1957 the Bushmans River (Oliff 1960a, 1960b). Brand *et al* (1967) carried out further surveys in 1965 and produced a synthesis on previous surveys. In 1984 and 1985 Mr B K Fowles re-surveyed many of the sites studied during the 1950's and 1960's in order to obtain some measure of changes that might have occurred in the intervening 30-year period. Unfortunately there was insufficient funding to analyse and report on all the rivers surveyed and only a preliminary assessment of selected samples from the Buffalo River, mostly from the stones-in-current (SIC) biotope, was conducted (Fowles 1986). These papers and reports analysed the status and abundance of the aquatic macroinvertebrates relating primarily to water quality.

An assessment of the instream flow requirements (IFR) of the macroinvertebrates of the Tugela River at selected sites was given by Chutter in Heinsohn (1995). In this report a number of indirect impacts on macroinvertebrates resulting from flow regulation by means of dams were listed. The importance of maintaining permanent flow and ensuring the correct seasonal distribution of high and low flow regimes was emphasised. The shortage of detailed information on the flow requirements of not only aquatic macroinvertebrates, but most freshwater biota was noted. It was therefore suggested that the modified flow regime should be managed in order to maintain existing biotope diversity. This could of course be reflected by measuring the diversity of selected aquatic macroinvertebrates especially species with stenotopic requirements. From this viewpoint the assessment of species presently found and an assessment of overall species diversity (being assessed in this study) will serve to provide a baseline measure of the present community of aquatic macroinvertebrates as well as to identify any biota which require special attention in order to maintain their conservation status. As a result of work done in previous surveys it is possible to make some assessments of the changes that have occurred in these river system since the 1950's. A long-term monitoring system which assesses the presence of selected species is necessary in order to make recommendations on flow regulations. This will help to prevent flow regulation practices which are detrimental to species which are earmarked for conservation.

In August 1999 a helicopter-survey and a visit to some sites by motor vehicle enabled a preliminary assessment of the diversity of aquatic biotopes along the Tugela and the Bushmans rivers, downstream of the proposed Jana and Mielietuin dam sites. Some collection of macroinvertebrates from selected biotopes along the Bushmans and Tugela Rivers was also undertaken. A one-week follow-up survey in early October allowed further collection, and although the samples collected could not be fully analysed, identification of selected material was carried out.

During the second survey, sites which were considered important for determining the species composition under prevailing flows and for assessing flow requirements of the instream biota, were selected for further survey purposes and study: SASS collecting techniques were used with the following modifications: as many biotopes as possible were sampled at each site, a fine mesh net (280 micrometre pore size) was used at most sites, and material collected from each biotope was preserved separately. In addition to the SASS

methods, other specialised collecting techniques were also used in order to sample as wide a diversity of macroinvertebrates as possible.

The 1999 survey revealed that the diversity of species in the Tugela and Bushmans rivers was different from those recorded in the 1950's. Because there was still a rich diversity of hydropneustic species it was, however, concluded that no significant changes in water quality or aquatic biotopes had occurred in the intervening 45 years. Construction of dams on the Tugela and Bushmans rivers would lead to significant modifications in the flow regime, thermal characteristics of downstream water and substratum composition. These would all have to be carefully monitored and managed so as to minimise the impact they would have on macroinvertebrate communities.

INTRODUCTION

The Department of Water Affairs are planning additional interbasin transfers of water from the Tugela and Bushmans Rivers to supplement the ever-growing demand for water in Gauteng. Before undertaking such a water transfer scheme it is important to consider the socio-political and biological factors that may be detrimentally effected by this development. The biological integrity of a river system must be cared for and an increase or decrease in flow can have deleterious influences on the riverine biota and impinge on the natural ecological functioning of the river. From a biological viewpoint it is important to consider whether there may be any transfer of undesirable biota from one catchment to another. The possible increase in pest species (in the donor or the recipient river systems) due to modified flow regimes, should also be considered.

A measure of the abundance and diversity of aquatic macroinvertebrates in a river provides information on the status or "environmental health" of that system. Because different species of invertebrates have a range of tolerances to various types of pollution and have varying aquatic life-cycle durations, the community structure of aquatic invertebrates can provide a time-integrated measure of the prevailing conditions. Such studies can, through the absence or presence of certain species, enable an assessment of the time of the disturbance and (in certain instances) what the form of the disturbance was (e.g. specific kinds of chemical or organic pollution or alterations in flow regimes). This is something which water chemistry samples, which give an instantaneous record of prevailing conditions, can not tell us. Because of their small size and relative sedentary nature, aquatic macroinvertebrates are vulnerable to ecological disturbances which can result in the elimination of certain biota from a section of river for some time. Unlike fish, macroinvertebrate species are not able to swim away from inhospitable conditions, and also need time to recolonise sections of river. Various macroinvertebrate species do this at differential rates.

Aquatic macroinvertebrates are important processors of organic matter. They serve a vital function in purifying the water in a river and also provide a valuable food resource for larger animals within and even outside the system. In order to continue functioning optimally, the component species in a river system require regular inputs of nutrients, sediments and water flow. Each specific river system is characterised by its own particular assemblage of species forming functional communities within reaches. These communities are optimally adapted to the prevailing flow conditions which control temperature, sediment transport and nutrient flows. A reduction or increase in flow, sediment transport or nutrient loads will lead to changes in community structure through loss of certain species and increases in others, as well as providing conditions for new- or otherwise-scarce species to flourish.

The brief given for this project was to assess changes in species diversity that might occur following construction of dams on the Tugela and Bushmans rivers. Information on the flow requirements needed to maintain the present diversity of biota in the donor river systems was also considered. In order to assess the flow requirements of these rivers it is considered important to determine the water quality and quantity requirements of the biota. As previous surveys were conducted around 45 and 15 years ago it was deemed necessary to determine what changes may have occured in the present river systems. Besides a re-survey of selected sites and a study of the previous surveys conducted, other published information on the aquatic biota of the Tugela and Bushmans Rivers was also consulted. All this information was synthesised to determine if there were any rare or endangered species, or possibly species with special environmental requirements that should be taken into account. Ideally the flows should be managed to ensure the survival of the extant communities along the river. Only if this is done, can good quality water be maintained for downstream users (biota and man). It is with this concept in mind that the structure of the invertebrate communities was examined.

To quantify the needs of the aquatic macroinvertebrates as regards physical water-flow requirements, an approach known as "Hydraulic Stream Ecology" has been developed (Statzner, Gore and Resh 1988). Habitat requirements of individual species are used to characterise requirements of the communities in specified biotopes. Factors such as current speed, depth and substrate characteristics are the major components considered. In South Africa, studies on instream flow requirements to accurately determine flow requirements of selected species have only been undertaken recently in selected rivers (King and Tharme 1994, Skorozewski and de Moor 1999). Extrapolation of requirements of particular species in one catchment to other species or even the same species in other catchments, have serious shortcomings. As one moves from rivers in a more temperate region to those in a more tropical realm, a reduction in flow and water volume will result in a concomitantly larger increase in water temperature. This will directly influence the dissolved oxygen levels in the water which are a controlling factor in enabling certain species to exist in a river. The height of the proposed Jana and Mielietuin Dams with proposed regular bottom-releases of water, would however lead to reduced temperatures of the river water downstream of the dam sites. This will negatively impact on life-cycle patterns of numerous species. With decreased temperatures in spring and summer, the insect pupae may not receive the right cues to enable completion of metamorphosis and emergence of adults. Bottom-released water will also be anoxic or low in oxygen and this too will decimate the species downstream of the water outlet.

Because of the time limitations for conducting the study (approximately two months from the inception of the project) a detailed survey of the riverine biota was not possible, and complete analysis of the limited data collected was not feasible. Data were also collected during extreme low-flows and would not reflect the greatest annual diversity of the river systems studied. A detailed survey would require sampling at all seasons, over a period of at least two years.

STUDY AREA AND METHODS

Figures 1-3 illustrate the sampling stations used during Oliff's (1960a, 1960b) repectively, Brand *et al* (1967) and Fowles' (1986) surveys. The additional sites surveyed during the helicopter and road surveys reported on here, are presented in Figure 4 and Table 1. Table 2 lists the samples from sites selected from B K Fowles survey in 1985 which had to be sorted and synthesised for the purpose of this study. Information on the topography, geology, rainfall and vegetation in the catchment is described in detail elsewhere (Oliff 1960a, 1960b; Brand *et al* 1967).

Between 1953-1961 Mr W D Oliff and colleagues undertook hydrobiological surveys of Natal rivers which included the Tugela and Bushmans Rivers (Oliff 1960a, 1960b; Brand *et al* 1967). Mr B K Fowles commenced a re-survey of Oliff's sites in 1984-1985 and, although the survey was completed, there was insufficient time to analyse the samples (Fowles 1986). Collecting techniques employed in these surveys were the same as those used by Oliff (1960a, 1960b) i.e. surber square foot bottom samplers, 62 mm diameter core sediment-samplers and hand nets. The nets used to sample aquatic biotopes for macroinvertebrates for the original survey of the main Tugela River had a pore size of around 1000 μm and in all subsequent surveys nets with a pore size of around 280 μm were used. Owing to time constraints only brief surveys were undertaken: a one-day helicopter survery and a one-day motor vehicle survey in August 1999 as well as a six-day follow-up collecting trip in October 1999.

During the Fowles 1985 survey 17 samples from the Tugela and 8 samples from the Bushmans River were collected.

During the late winter - spring survey of 1999, four sites along the Bushmans and 14 sites along the Tugela River were surveyed (Figure 4, Table 1, Plates **1-xx refer to Roy Wadesons digital photos?**). River flow at this time of the year is normally low, prior to the high summer flows. This allows easy access to the main river channel. This season is characterised by increasing water temperatures and the emergence of the adult stages of many aquatic insects. It is therefore a favourable time for collecting adult macroinvertebrates by means of light traps.

Photographic records were made of the general aquatic environment at each sampling site. This represents a visual record of aquatic biotopes present and also gives a general idea of the prevailing conditions at the time of sampling. Aquatic invertebrates were sampled using various water- and aerial hand nets ranging in net mesh size from 80 micrometres (0.08 mm) to 1000 micrometres (1 mm). Sampling of aquatic stages was done using a standard SASS net (mesh size 1000 μm); a hand-net (mesh size 280μm); a small D hand-net (mesh size 80μm) for sampling bedrock in swift-flowing reaches and the hygropetric splash zones of waterfalls. A large coral or kraal net (mesh size 1000 μm) was also used to sample riffles and sandy river beds thus ensuring the capture of rapid-swimming invertebrates which might escape from smaller nets. General hand-picking of stones, lodged branches and removable substrates was also carried out. As many aquatic biotopes as possible were sampled at each site (Table 1). Light traps, to collect the adult stages of many aquatic insects important for species identification, were set up at several sites. Where time permitted, general collecting of flying adult insects was also carried out.

The biotopes sampled included stones in and out of current, marginal vegetation and root stocks, floating and submerged aquatic macrophytes, filamentous and encrusted algae, sediments on substrata, the surface of water bodies, adult flying insects with aquatic nymphal and larval stages, and insects attracted to light traps. A light trap using a super-actinic light source over a white tray was used where conditions were suitable. Sheet light traps, which allow selective collecting and rearing of mayfly sub-imagoes to the adult stage (needed for species identification) were also used. Biotopes were sampled in a number of ways: Invertebrates associated with aquatic plants were collected by running a net through aquatic macrophytes and marginal vegetation. Aquatic macrophytes were also collected and examined and, where stony substrata were present, stones were lifted and brushed by hand or washed into a collecting net. Aquatic animals were also picked off these stones with a fine pair of forceps or by hand. Sediments were stirred up and either a coarse- or fine-meshed net was run through disturbed sediments and substrates. Where running water was found, stones in the flowing current were dislodged and kicked and invertebrates were carried by the current into a net suspended below the disturbed substrates. A synopsis of all biotopes sampled at each site is given in Table 3.

Unsorted samples from both the 1985 and 1999 surveys, as well as selected animals collected, were given a catalogue number for each site, date and biotope. Samples were labelled and preserved in either 80% ethanol or 4% formaldehyde. Selected samples were sorted in the laboratory by first picking out large animals and then passing each sample through a series of nets of different mesh-sizes to separate large and small invertebrates. A final check of each sample with a dissecting microscope was carried out to remove any smaller animals that could be missed in the coarse sorting.

Identification of selected animals were carried out using museum-voucher material for comparison, and where specimens of particular species were not available, the library of taxonomic papers held by the Albany Museum was used. Certain groups will be sent away to specialists for more detailed identification and the remainder of samples which could not be identified in the present survey, will be stored for sorting and identification at a later date. All material collected will be stored and curated in the Albany Museum, Grahamstown. Material will be stored under the Tugela River catalogue (TUG) or the Bushmans River catalogue BUS). The collection contributed 58 separate TUG and 22 separate BUS catalogue entries. Samples have been sorted and given individual species identification labels under the specific river catalogues.

The collection contributed about 800 separate catalogue entries and about 15000 specimens.

RESULTS

Tables 4 and 5 present the recorded taxa collected along the Tugela and Bushmans Rivers. In addition to information gathered during the surveys, taxa collected and reported on in other literature as well as that held in the National Collection of Freshwater Invertebrates at the Albany Museum are also included. Papers consulted for this include (Barnard 1932, 1934, 1937, 1940, Crass 1947, Demoulin 1970, McCafferty 1971, McCafferty and Gillies 1979, Scott 1983, de Moor 1993).

The surveys conducted by W D Oliff and colleagues produced an extensive list of species (Tables 4 and 5). This was compiled over a number of years comprising numerous visits to various regions along the river systems and included extensive summer time collecting with hand nets and other techniques. Analysis of selected taxa gathered during the present survey is presented in these two tables. With the limited time available for collecting and the requirements of other specialists to assist with the identification of many of the taxa, it was not possible to present an exhaustive review of the taxa that were found along these rivers. More intensive sampling would be needed in the summer and preferably extending over several years, to ensure coverage of species found during different seasons and during average and wet or dry years. Odonata in particular would require specialist collecting techniques to allow proper assessment of the species present.

A COMPARISON OF THE MACROINVERTEBRATE FAUNA BETWEEN 1953 AND 1999

The main purpose of the 1985 survey carried out by B K Fowles was to compare the community or assemblage of macroinvertebrates with the surveys carried out in the 1950's. The techniques used were thus carefully selected to be similar, although the mesh sizes of nets used in surber samplers for the Tugela River were smaller for the 1985 (c. 280 micrometres) than for the 1953 (c. 1000 micrometres) survey.

A major problem with comparing the faunal composition of species from the 1950,s and 1985 with the more recently-collected samples, is that different techniques and net pore sizes were used. In the 1950's and 1985 Surber samples were used to sample stones-in-current biotopes whereas in 1999 SASS nets, 280 µm mesh hand nets, coral nets and kicking of substrates were used. All these techniques would inadvertently pick up a percentage of organic drift. The SASS net technique would under-collect sesile organisms such as Simuliidae and, because a courser mesh size (1000 µm as opposed to 280 µm) is used, smaller animals such as certain species of entomostracan Crustacea, Chironomidae and oligochaete worms belonging to the genus *Nais,* would be under-represented and this would give a skewed representation as regards the dominance of different species. Oliff (1960a) reported that a reduction in the pore size of sampling nets from 1000 µm to 280 µm resulted in a two-fold increase in the abundance of animals collected. This would naturally influence the dominance and representation of species in community analysis. The sites selected for the 1999 survey are also not the same as sites used during earlier surveys and, although the locality of certain sites was close to those of earlier surveys, this discrepancy adds to the level of uncertainty in comparisons. The purpose of the 1999 survey was to obtain a maximum estimate of species diversity rather than to carry out an extensive quantitative analyses of species abundances in different biotopes.

Because of time constraints the level of identification of many of the invertebrate groups could not be carried down to species level in this study. Ostracoda, Cladocera and Copepoda as well as certain families of Diptera, Coleoptera and Hemiptera, were not identified to the highest possible level but will be further identified with more time and specialist identification services. By the same token the Ephemeroptera, Trichoptera and Diptera (Simuliidae) were identified with far greater resolution in 1999 than in the earlier studies as a result of the improved knowledge and understanding of the systematics of these biota. For this reason a far greater heuristic value can be attached to identifications carried out with a modern phylogenetic approach, and better predictions can be made with regards to the expected presence or absence of different clades (groups of related species). Where material from the earlier surveys was preserved as voucher specimens, it was possible to go back to these old collections and check previous identifications.

The Tugela River

Table 4 shows that the detail of species identification varies. For many taxa (Turbellaria, Nematoda, Annelida, Crustacea, Odonata, Hemiptera, Dytiscidae, Chironomidae) identifications to species-level were conducted on most of the material in the 1950's, and this could not be done for the present survey. All the major groups are present and await further identification. For other groups more effort has been spent on ensuring accurate identification and, using more modern phylogenetic classification of groups like the Ephemeroptera, Trichoptera and Simuliidae, a considerable improvement on what was known in the 1950's and 60's has been made. Many name-changes have been taken into account and in Tables 4 and 5 the most recent taxonomic names have been used and have also been applied to the material from the 1950's and 60's. Mollusca too have been more accurately identified and more species are recorded for both the 1999 and synthesis of the 1985 survey.

Planorbid snails, including the vector of urinary bilharzia *(Bulinus tropicus),* were found at several sites during the 1985 and 1999 surveys (Table 4). These were not recorded in the 1953/54 survey. Increasingly lower flows in the river will favour these snails and will lead to a concomitant increase in bilharzia.

It was noted that no freshwater crabs (Potamonautidae) were collected during 1985 and 1999 surveys. Atyiid shrimps *Caridina* spp. were common in marginal vegetation in the lower reaches of the Tugela River in the Valley Sand Bed (Zone 7) and freshwater prawns *Macrobrachium vollenhoveni* were found in riffles and stoney runs at station 8 (corner of Khaisha Farm, about 10 km downstream of the proposed Jana Dam site). This species becames progressively more abundant at all sites in riffles further downstream.

The dragon and damselflies (Odonata) represent the best-studied aquatic order of insects in South Africa and are represented in this region by 162 species (Pinhey 1984, 1985). All nymphal stages and the adults are carnivorous and feed mostly on other insects. Identifying Odonata to species level requires the collection of adults which can only be effectively collected with hand nets in the day-time during the hot summer months of the year. Several days of dedicated collecting at each site would ensure a good representative selection of species. Unfortunately, the time and manpower did not allow for this type of collecting and only nymphal Odonata collected are incorporated in Table 4.

A nymph of *Paragomphus* was found at most sites surveyed in 1985 and 1999. A number of species of Libellulidae were commonly found. *Zygonyx* sp. usually associated with stoney substrates in swift-flowing water were found at most sites in the Tugela River.

During 1953/55, 1985 and 1999 respectively 41, 21 and 30 species of Ephemeroptera were recorded along the main Tugela River. Only zones 4-7 were surveyed during 1985 and 1999 and this therefore reflects a better understanding of this order of insects for the latter survey. Unfortunately specimens collected in the 1950's were not always retained as voucher material and many eroneous identifications or refinement of identifications could thus not be checked.

Two species of burrowing mayflies were collected in the 1953 survey (Table 4, Table 6). No species were found during the 1985 and 1999 surveys. These species require a sand/clay substrate in which they make U-shaped burrows, using their feathery gills to create a water current through their burrows, thus bringing food particles to these nymphs. These species are very dependent on flow type. Changes in the flow regime can alter the nature of the substrate and hence their preferred biotope. This eventually affects their survival in a river. It is likely that these species would be found in the foothill sandbed region (Zone 5) which was not extensively surveyed during 1985 or 1999.

The number of Baetidae species recorded during the earlier 1953/54 survey was considerably higher than in the two more recent surveys (23 species as opposed to 12 and 15 respectively for 1985 and 1999). This was mostly because the data presented in the 1953/1954 survey reflected a much longer collecting period, and also covered the upper reaches of the river in greater detail. Little information on the flow requirements of the Baetidae has been recorded. Generally, species such as *Baetis harrisoni, Pseudocloeon glaucum*, *P. vinosum*, *Cheleocloeon excisum* and *Afroptilum sudafricanum* are widespread and able to survive under a variety of conditions, whereas the *Demoreptus* species tend to be more specific in their flow requirements, needing fairly rapid flow and clean water. *Potamocloeon macafertiorum* has long slender claws typical of psammophilous species, and occurs in reaches where the flow is slower and the substrate sandy.

The Caenidae are a family still needing major taxomomic revision, although several distinct species can be recognised. The most interesting is *Clypeocaenis umgeni*, which has filtering hairs on its legs and mouthparts. This species inhabits faster flowing water compared to many of the other members of the Caenidae which generally live in slower flowing regions or out of the current, where in silt deposition occurs. The taxonomic knowledge in the 1960's was inadequate to recognise the diversity of species.

In the family Leptophlebiidae, only the tolerant *Euthraulus elegans* was collected in the 1999 surveys. It was also the only leptophlebiid species recorded below zone 4 in the earlier surveys.

The flat-headed sprawling Heptageniidae cling to stones in moderate to fast-flowing current, and their distribution and abundance may also be affected by changes in flow conditions in a river. They were recorded lower downstream in 1985 and 1999 than in the 1950's.

The presence of Sisyridae, *Ceraclea (Pseudoleptocerus*) sp. and *Xenochironomus* sp. (all associated with freshwater sponges) which were not recorded previously, is also noteworthy. It is unlikely that freshwater sponges and their associated fauna are a recent introduction in the river, but an increase in the abundance of these species would indicate changes in the general river ecology. A greater abundance of fine filter-feeding organisms such as freshwater sponges and Simuliidae would indicate an increase in detritus and associated bacteria in the system.

During 1953/55, 1985 and 1999 respectively 23, 11 and 18 species of Trichoptera were recorded along the main Tugela River (Table 7). Only seven species were found during both 1953/54 and 1999. This is partially due to more detailed surveys of the upper reaches of the river in 1953/54 and also because rare taxa were taken into account and could easily be missed in a one-off survey. Some confusion exists with the identification of two species *Hydropsyche ulmeri* and *Cheumatopsyche thomasseti* from larval material. These associations seem uncertain and need further resolution. There may thus be a double recording of some species in the present report. Further examination of adult Hydropsychidae collected could reveal more species for the 1999 survey.

All the aquatic moths collected belong to the family Pyralidae. Rock-dwelling species feed on diatoms and algae, other species feed on aquatic and submerged plants. One and three different species were respectively collected in the 1985 and 1999 surveys.

During 1953/55, 1985 and 1999 respectively 7, 7 and 8 species of Simuliidae were recorded along the main Tugela River (Table 8). Only three species were found during both 1953/54 and 1999. This is partially due to more accurate identification of simuliid larvae during the 1985 and 1999 surveys, and this is borne out by the fact that all except one species was recorded during both of these surveys (Table 8). The presence of *Simulium dentulosum* and *S. debegene* in zone 5 during the 1953/54 survey is indicative of strong torrential flows and would indicate that this was in the upper reaches of zone 5 in the Tugela River.

The Bushmans River

The macroinvertebrate faunal diversity in the Bushmans River was not as rich as that of the Tugela River (Table 5). During the 1985 and 1999 surveys respectively, 4 sites and 8 biotopes and 4 sites and 10 biotopes were surveyed in the Little Bushmans and Bushmans Rivers (Tables 1 and 2). Not all samples have been analysed and the data presented reflect only a preliminary assessment of what was found.

Freshwater sponges and associated Sisyridae larvae were also recorded for the first time in this river system. As for the Tugela River, freshwater crabs Potamonautidae were also not collected in either the 1985 nor 1999 surveys. Atyidae and Palaemonidae were recorded in 1999.

Only five species of Baetidae were identified from the Bushman's river sites from the 1999 survey, as opposed to 13 species reported by Oliff (1960) (Table 5). However, a few interesting species not reported by Oliff include *Cloeodes inzingae*, *Demoulinia crassi* and *Pseudocloen aquacidium*. Much change has taken place in recent years in the taxonomy of the African Baetidae, and it is possible that certain species may have been overlooked or mis-identified in the earlier collection. *Demoulinia crassi* is known to occur in still deep stretches of river, and like the *Potamocloeon* species (not recorded from the Bushman's River), it dwells on the surface of sandy substrates where it collects detritus upon which it feeds.

No burrowing mayfly species (Oligoneuriidae) were recorded from this river. They had possibly already been excluded by the effects of pollution already in the 1950's.

Perlidae stoneflies were recorded for the first time in 1999. This may indicate some improvement in water quality, but may also reflect the fact that this species, although it may have been present was not recorded previously.

The reports written between 1960 and 1967 recorded 11 species of Trichoptera. In the 1985 and 1999 surveys respectively 4 and 10 species of Trichoptera were recorded. Light-trap collecting produced 5 of these records. Of the ten species recorded in 1999 only four were also recorded prior to 1967. This either indicates a significant change in species composition or it reflects differences due to the use of different sampling techniques.

The number of simuliid species recorded for 1960, 1967, 1985 and 1999 were 5, 0, 1 and 10 respectively. This reflects a more intensive survey for these species and also a greater level of identification during the most recent survey. It is to be expected that the simuliid species diversity would be greater than that recorded during 1967 and 1985. The sites surveyed during 1985 were mostly near Estcourt where pollution from factory and sewage effluent was high and would have lead to reduced species diversity. The 1967 report included only the MVIC biotope, hence reflecting a limited substratum for simuliid colonization. This was also seen in the Trichoptera. Of particular note was the rich diversity of *Simulium (Metomphallus)* species. *S. medusaeforme, S. hargreavesi, S. vorax* and *S. wellmani* were all represented. As discussed below these species are indicators of swift flowing water and their species diversity reflects heterogenious substrate types and a diversity of flow conditions. Species in the subgenus *Simulium (Pomeroyellum)* were also represented by three species. Their affinities and flow requirements are discussed below. The most interesting find was a single larva of *Simulium lumbwanum* (found at site 4 on the Bushmans River) a species which is phoretic on Heptageniidae mayflies. Further research is needed to investigate this discovery.

Even with the limited data available, it is possible to conclude that no further serious deterioration of water quality has occurred in the lower reaches of the Bushmans River since the 1960's. A rich diversity of hydropneustic aquatic insects indicates that the water was of a relatively good quality especialy at the lowermost site in the Bushmans River.

ZONATION IN THE TUGELA RIVER

Oliff 1960a proposed a zonation for the Tugela River (Figures 6 and 7) and a more detailed examination of the distribution of Ephemeroptera, Trichoptera and Diptera (Simuliidae) along this zonation is undertaken (Tables 6-8).

Ephemeroptera

Oliff (1960) identified eight hydrological zones within the main Tugela River. These are: (1) the source zone, (2) the waterfall zone, (3) the mountain torrent zone, (4) the foothill torrent zone, (5) the foothill sandbed zone, (6) the rejuvenated river zone, (7) the valley sandbded zone, and (8) the estuarine zone. In early October 1999, a survey of the main Tugela River was conducted to assess the diversity of its mayfly fauna. Emphasis was given to Oliff's (1960) zones 6 and 7. Upstream and downstream differences in the composition of the mayfly fauna within these zones are discussed below. Numbered sites mentioned correspond to numbered sites in Table 2, Fig. 4.

Sites 8, 9, 10, 11, and 12 are within Oliff's (1960) zone 6. Site 8 is upstream and site 12 is downstream. Site 8 is relatively poor in its composition, with only five mayfly species found. These species are, in descending order of abundance: *Baetis harrisoni, Pseudocloeon glaucum, Afronurus peringueyi, Centroptiloides bifasciata,* and *Clypeocaenis umgeni.* Site 9 is the most diverse, with 14 species. These species are, in descending order of abundance: *Pseudocloeon glaucum, Baetis harrisoni, Euthraulus elegans, Caenis* sp. 6, *Afronurus peringueyi, Pseudocloeon vinosum, Centroptiloides bifasciata, Caenis* sp. 3, *Cheleocloeon excisum, Potamocloeon macafertiorum, Cloeon africanum, Caenis* sp. 2, and *Compsoneuriella bequaerti.* Only four species were collected from site 10. In descending order of abundance, these species are: *Pseudocloeon glaucum, Afronurus peringueyi, Baetis harrisoni,* and *Caenis* sp. 5. Only two species were found in equal numbers in site 11. These species are *Baetis harrisoni* and *Caenis* sp. 3. No data is available from site 12.

Sites 13, 14, 15, 17, and 18 are within Oliff's (1960) zone 7. Five species were collected from Site 13. In descending order of abundance, these species are: *Euthraulus elegans, Afronurus peringueyi, Pseudocloeon glaucum, Clypeocaenis umgeni,* and *Centroptiloides bifasciata.* Nine species were collected from site 14. These species are, in descending order of abundance: *Pseudocloeon glaucum, Baetis harrisoni, Afronurus peringueyi, Tricorythus discolor, Euthraulus elegans, Acanthiops tsitsa, Crassabwa flava, Prosopistoma crassi,* and *Centroptiloides bifasciata.* Nine species were also collected from site 15. These species are, in descending order of abundance: *Pseudocloeon glaucum, Baetis harrisoni, Centroptiloides bifasciata, Euthraulus elegans, Tricorythus discolor, Clypeocaenis umgeni, Caenis* sp., and *Pseudocloeon vinosum.* No data is available on site 17. Four species were collected from site 18. These species are, in descending order of abundance: *Pseudocloeon piscis, P. vinosum, Cheleocloeon excisum,* and *Caenis* sp.

In both zones, the most abundant species are *Baetis harrisoni* and *Pseudocloeon glaucum. Afronurus peringueyi* and *Euthraulus elegans* are also abundant. *Centroptiloides bifasciata* tends to be found at all sites, but in low numbers. The middle reaches within each zone (site 9 for zone 6 and sites 14 and 15 for zone 7) are the most diverse (see above). Zone 6, with 16 species, has a slightly more diverse mayfly fauna than zone 7, with 14 species. Rare species found in both zones include *Acanthiops tsitsa, Clypeocaenis umgeni, Crassabwa flava, Prosopistoma crassi, Potamocloeon macafertiorum,* and *Compsoneuriella bequaerti.*

Trichoptera

The highest diversity of Trichoptera species (Table 7) was found in zone 4 in the 1953/54 survey with 14 recorded species. Ten and 11 species were collected in the rejuvenated River (zone 6) during 1953/54 and 1999. Surveying of reaches with riffle bars in the Sand Bed River (zone 7) indicated the presence of 10 species in 1999, whereas only 5 were recorded in 1953/54. A downstream zonation of hydropsychid species was evident from the limited data analysed. The dominant hydropsychid during 1999 in zone 4 was *Cheumatopsyche* sp. 5. During 1985 the dominant species in the upper reaches of zone 5 were *Cheumatopsyche* *thomasseti* and *Amphipsyche scottae*. During 1999 *Hydropsyche longifurca* was present in zones 4 and 5 and the uppermost site of zone 6 (Station 8) in the Tugela River. This species was not found further downstream during the 1985 or 1999 surveys. The dominant species of hydropsychid in zones 6 and 7 during 1985 and 1999 were the larvae of *Cheumatiopsyche* sp. 2. *Cheumatiopsyche* sp. 9. was found in lower numbers, but was also present at sites higher upstream.

Two species of hydroptilid caddis (*Hydroptila cruciata* and *Orthotrichia barnardi*) were common in zone 7 of the Tugela River during 1985 and 1999. Leptocerid caddisflies were represented by 6 species but were never abundant. Light-trap sampling enabled the collection of several species not recorded from benthic sampling. It was notable that Ecnomidae were rare in light trap samples which were dominated by hydropsychid Trichoptera at all sites surveyed.

Simuliidae

A zonation of *Simulium* species was discernible from the upper reaches down to the coast. *Simulium dentulosum* and *S. debegene* were recorded in the uppermost zones in 1953/54 and are the most commonly-occurring simuliids in the upper mountain torrent regions.
There were several species within the sub-genus *(Metomphallus)* collected in this survey and *Simulium medusaeforme* was the most widespread species and was found all the way down to the lower zone 7 (site 17). *S. medusaeforme* is considered to be an adaptable species found under a wide range of flow conditions. It is common in the swift-flowing middle reaches of larger rivers where it dominates the simuliids numerically. *Simulium wellmani* was another species which was found in the middle reaches. Its distribution was more restricted to the upper-middle reaches (Zones 4 and 5) than *S. medusaeforme. Simulium vorax* (recorded in zones 6 and 7) is often found together with *S. medusaeforme* but it is usually the dominant species in larger rivers with a greater flow volume and velocity. Owing to the very low flow conditions during the 1985 and 1999 surveys, this species was rare. *Simulium bovis* was only found in the two lowermost zones 6 and 7, and appears to be restricted to the lower river reaches where turbidity is high and flows may fluctate considerably.

GENERAL CONCLUSION AS TO THE CHANGE OF SPECIES RECORDED OVER 45 YEARS

Regarding species composition of known taxa, the fauna has not changed very much over a 45 year period for both the Tugela and Bushmans Rivers. Ephemeroptera and Trichoptera are still diverse and represent two of the dominant taxonomic groups.

The early surveys showed clearly that the upper reaches of the Tugela River (identified as the mountain and foothill torrent zones in Oliff's 1960a paper) had a distinctive fauna. The present survey did not take these regions into account, and discussion of the unique fauna remains only as a mention in tables 4-8.

FLOW REQUIREMENTS OF SELECTED AQUATIC MACROINVERTEBRATES

Ephemeroptera

Oligoneuriidae

These mayflies are filter feeders in the nymphal stages and live in swift-flowing waters. They rely on the flowing water to carry food to them and they collect the food by means of filtering hairs on the front legs. Highly modified mouthparts are used to scrape filtered material off the filtering hairs. *Oligoneuriopsis lawrencei* is restricted to the upper reaches of the river (Zone 3) and large perennial streams at altitudes over 1100 m asl. The flow requirements for this species, from previous collecting experience, are swift to torrential flows with large boulders or cobbles forming suitable substrates. Agnew (1973, 1980) provides compelling evidence to confirm that this species, as expected for all Oligoneuriidae, is univoltine and needs perennially-flowing water. Overwintering diapause eggs are evidently laid. These remain dormant for about six months before nymphs hatch in the ensuing spring and develop through to adults during late summer to autumn. It is also noted that *Oligoneuriopsis* species are "cold adapted" species and need cool, well oxygenated water throughout the summer period to complete development.

The oligoneuriid *Elassoneuria trimeniana* recorded from zones 5-7 in 1953/54 is also a species requiring a strong flow of water. This species was not recorded in the 1985 or in the 1999 survey. As this species is also univoltine, it may have been present as small larvae and would not have been detected during the late winter and spring seasons when the surveys in 1985 and 1999 were conducted. Adult *E. trimeniana* were found in a light trap sample collected by Mr Conor Cahill in April 1999, indicating that this species is still found on the Tugela River. Perennial flow also seems to be a requirement for maintaining populations of this species, although species of the genus *Elassoneuria* are found at lower altitudes and warmer waters than *Oligoneuriopsis* and hence may not need such abundant flows to maintain cool temperatures as required by the latter genus.

Baetidae

These include the species such as *Centroptiloides bifasciata* a large predatory species found only in the swiftest flowing water on large boulders and stones (it soon dies when left in stationary water) and *Pseudopannota maculosa* (which was not recorded during the extremely low-flow conditions when the survey was conducted in 1999). Both these species would not prosper under prolonged reduced-flow conditions.

Prosopistoma crassi (Prosopistomatidae) is widespread in tropical waters. Flow requirements for this species appear to be associated with conditions creating substrates predominantly composed of large cobbles to boulders i.e. flows exceeding 0.8 ms^{-1} (Hynes 1970).

Tricorythus discolor and *T. reticulatus* were found in eroding biotopes in the river. Oliff (1964) found that silt deposits restricted the distribution of these species. They are, however, tolerant of moderate pollution and a moderate to swift flow regime.

Trichoptera

Hydropsychidae

The filter feeding hydropsychids *Cheumatopsyche thomasseti* and *C. afra* are widespread and tolerant species. The ecological requirements of *Hydropsyche longifurca* are less well understood but this species is often found in association with the above two species and is larger than any of the *Cheumatopsyche* species found in the Tugela River. The several other species of hydropsychid found are less well known as regards their ecological requirements. It would seem that the larvae of *Cheumatopsyche* sp. 2, the most abundant of hydropsychid species encountered during the 1999 survey, are those of *C. falcifera*, and that flow velocity and substrate type and depth requirements for this species are similar to those of *C. thomasseti.* All the above-mentioned species need a strong flow of water over riffles or rapids to keep stone surfaces cleared of sediment and to support their silken collecting nets with which they capture organic matter (including other insects and algae on which they feed). They are all multivoltine going through several generations a year. Synchronisation of spring emergences plays an important part in controlling pest blackfly population levels in medium to large rivers (flows of over 5 cumecs) (de Moor 1992).

Simuliidae

Simulium damnosum s.l. is recognised as a species complex with more than 40 described Afrotropical species, most of which are distinguishable only on cytological and behavioural characteristics. The species from the Tugela and Bushmans Rivers was found in swift flowing sections of the river in riffles and on marginal vegetation all the way down to the coast.

Simulium adersi was found in Zones 6 and 7. This species is a widespread pollution- and saline-tolerant species, usually found in slow-flowing, medium-sized rivers with a stable flow regime. *Simulium adersi* has been recorded biting man in the eastern Cape.

Species in the subgenus *Simulium (Metomphallus)* (see above for a list of species found) require swift flowing conditions (ranging from 0.8- 1.5 ms^{-1}), with clear bedrock or large boulders and stones in larger streams and rivers. They form the dominant component of swift-flowing African Rivers.

The larvae of species belonging to the subgenus *Simulium(Pomeroyellum)* which included *Simulium mcmahoni, S. rotundum* and *S. cervicornutum* are found in slow- to moderately swift-flowing water 0.2-1.0 ms^{-1} attached sparsely either to stones, dead leaves or vegetation. These three species are often found in shallow flowing warmer water under sub-tropical conditions.

DISCUSSION

The Tugela and Bushmans rivers show a rich diversity of Ephemeroptera (Tables 4, 5 and 6). All except one of the South African families, the Teloganodidae, are found in these rivers.

The Trichoptera are not as diverse, being represented by eight of the 18 families recorded in South Africa. Sampling for species in specialised biotopes would undoubtedly reveal more species, but this was outside the scope of the preliminary survey.

A characteristic of the Tugela River is that it arises on an escarpment, drops almost vertically 850 metres via waterfalls to a mountain torrent zone, and then rapidly grades into a foothill torrent zone. The river then flows over a gentle gradient through a foothill sandbed zone for about 40 km up to the town of Colenso. Pool-like conditions and meandering stretches of the river prevail here. There is then an increase in the gradient, creating many rapids and riffles within a swift-flowing river (designated as a rejuvenated zone by Oliff, 1960a). This extends down to the confluence with the Buffalo River. From there the river widens into a Valley Sand Bed zone where deposition of sand predominates the channel. In these lower reaches there are still sections of river where granite and gneiss riffle bars extrude into the sandbed creating short reaches of cascades, riffles and rapids interspersed with longer reaches of sandbed river. The river then flows into a broad estuary.

The above range of conditions has allowed for the observed diversity of macroinvertebrates found in this river (Table 4).

IMPACTS ON THE RIVER ECOLOGY RESULTING FROM THE TWP

The proposed construction of the Jana and Mielietuin Dams will defininitely affect the fauna in a number of ways:

The downstream zonation observed in the Ephemeroptera, Simuliidae and hydropsychid Trichoptera will be disrupted and it is likely that ubiquitous species such as *Simulium nigritarse, S. adersi, S. medusaeforme* and to an extent *S. damnosum* s.l. will become more abundant. Species such as *Simulium vorax* will become rarer. It is not possible to accurately predict what species assemblages will develop. There will be definite changes in functional communities of species.

A modification of the thermal regime with much colder water being discharged from the bottom of the dams at regular intervals will have a devastating effect on the macroinvertebrate biota. The gradual natural seasonal decrease in autumn through winter followed by a gradual increase of water temperatures in spring will be completely disrupted. Irregular temperature fluctuations will upset the biological rhythms of many species, and aquatic insects will fail to pupate, metamorphose or emerge. Certain adaptable species will become abundant and pose pest problems which will be costly to control.

Besides a change in the thermal regime, resulting from bottom releases of water, toxic reduced ammonia and hydrogen sulphide will be released and can cause a kill-off of all life downstream of the dam if not carefully managed.

Reduced sediment loads in swift-flowing water immediately downstream of the dam will lead to increased erosion capacity and this will lead to exposure of bedrock (armouring) in these reaches. Species community structure will be disrupted with no detritus for detrital feeding species. Such conditions will favour bedrock-dwelling species i.e. certain species of

Simuliidae.

The Tugela and Bushmans Rivers have a mixture of suspension filter feeders and detritus feeders with low numbers of grazers. Reduced input of detritus and particulate matter in the river downstream of the dam sites will influence macroinvertebrate community structure. Rather than a total elimination of certain species there will be subtle changes in species dominance and a gradual change in the functional ecological role of species found. Such changes will favour more generalist species and lead to a reduction in more narrowly-specialised species. These changes could be associated with feeding, cryptic behaviour, breeding and seasonal emergence patterns.

Less sediment in the water will lead to a greater clarity of water leading to greater penetratration of light and more algal and plant growth on substrates downstream of the impoundment. Greater clarity of the water will make species more vulnerable to predators dependant on vision and again this will lead to subtle changes in species composition.

Clear water in the dams could lead to algal blooms with plants getting into the river dowstream of the dam. This will favour certain filter-feeding species such as simuliids and certain Hydropsychidae.

Much further downstream of the Dams, lower flows will lead to increased sedimentation of riffles and a loss of braided sections of riverbed in wide riffle-bar reaches. This will lead to a reduction in the heterogeneity of substrata and aquatic biotopes which will lead to a concomitent reduction in species diversity. This could have dire effects on the river ecology as there will then be a few dominant species which will periodically develop into pest proportional population sizes.

RECOMMENDATIONS

Ecological requirements of the biota are strongly governed by the flow and thermal regime of the river and modification of sediment deposition or erosion, and seasonally-unnatural low or high temperatures, as well as rapid fluctuations in temperature, will lead to species eradication and functional community structural changes.

To assess in greater detail whether there are rare or endangered species as well as concentrations of potential problem or pest species along the course of the rivers, a two-year, in-depth survey of benthic macroinvertebrates in the late winter and late summer as well as light trap and adult insect collecting in summer should be conducted.

As a management proposal for the Tugela River it is reccommended that efforts should be made, at least to maintain and if possible try to improve, conditions that will enhance the diversity of filter feeding species in the riffle- and running water biotopes. Maintenance of sediment-free substrata and prevention of clogging of interstices in riffles should be managed. The lower sandbed reaches in zone 7 have braided channels with riffles, cascades and rapids as well as islands of macrophytes. These biotopes should be accounted for in designing a new flow regime. The maintenance of a diversity of biotopes in these lower sandbed reaches will ensure that no single group of animals will dominate the fauna of the river. Maintenance of species diversity will ensure that pest species, such as certain *Simulium* spp. and bilharzia-vector snails, do not become abundant, a problem which would have to be further managed.

The presence of a mixed community of filter-feeding and gatherer-collector species characterised the Tugela and Bushmans Rivers for all sites surveyed. There are many species that require a regular input of detritus and sediment for continued survival. Careful management of the thermal regime should also be considered in the river management programme.

A regular monitoring programme should be developed to ensure that the recommendations are met. A late winter/dry season survey of benthic macroinvertebrates should be undertaken annually. In addition, a late summer survey with light traps (to collect adults) should be implemented. The monitoring programme should cover the following:

* An in-depth two year survey to develop a base-line data set for determining the species diversity and relative abundance of key taxa
* Annual monitoring of species diversity
* Annual determination of the relative abundance of selected species

ACKNOWLEDGEMENTS

Cliff Zingela and Mbongeni Baninzi assisted in sorting samples. We would also like to thank Irene de Moor for help with preparing the tables and figures. Mike Coke accompanied us on the first survey and put up with the irregular hours of sampling activity during a four-day visit to the Bushmans and Tugela rivers.

REFERENCES

Agnew J.D. 1973. Two new species of *Oligoneuriopsis* Crass from the Republic of South Africa (Oligoneuriidae: Ephemeroptera. pp. 114-121. *In:* Peters W.L. and Peters J.G. (eds). Proceedings of the first International Conference on Ephemeroptera. E.J. Brill, Leiden.

Agnew J.D. 1980. A systematic study of some Ephemeroptera in southern Africa. Ph.D Thesis University of the Witwatersrand Johannesburg. 247 pp.

Barnard K.H. 1932. South African May-flies (Ephemeroptera). *Transactions of the Royal Society of South Africa* **20**: 201-259.

Barnard K.H. 1934. South African caddis-flies (Trichoptera). *Transactions of the Royal Society of South Africa* **21**: 291-394.

Barnard K.H. 1937. A new May-Fly from Natal. *Annals of the Natal Museum* **8**(2): 275-278.

Barnard K.H. 1940. Additional records, and descriptions of new species, of South African Alder-flies (Megaloptera), May-flies (Ephemeroptera), Caddis-flies (Trichoptera), Stone-flies (Perlaria), and Dragon-flies (Odonata). *Annals of the South African Museum* **32**(6): 609-661.

Brand P A J, Kemp P H, Oliff W D and Pretorius S J. 1967. Water Quality and abatement of pollution in Natal Rivers. Part III. The Tugela River and its tributaries. Natal Town and Regional Planning Reports **13**(3):1-92.

Crass, R.S. 1947. The May-flies (Ephemeroptera) of Natal and the eastern Cape. *Annals of the*

Natal Museum. **11**: 37-110.
de Moor, F.C. 1992. Parasites, generalist and specialist predators and their role in limiting the population size of blackflies and in particular *Simulium chutteri* Lewis (Diptera: Simuliidae) in the Vaal River, South Africa. *Ann. Cape Prov. Mus. (nat. Hist)* **18**(13), 271-291.
de Moor F.C. 1993. Factors influencing the distribution of Trichoptera in South Africa. pp. 51-58 *In*: Otto C. (ed.) Proceedings of the 7th International Symposium on Trichoptera. Backhuys Publishers Leiden, the Netherlands. 312 pp. Demoulin, G. 1970. Ephemeroptera des faunes éthiopienne et malgache. *South African Animal Life* **14** 24-170.
Fowles B.K. 1986. Chemical and biological resurvey of the Rivers of the Tugela Basin. Natal Rivers Research steering committee Progress Report No. 67.
Heinson, D. 1995. *Tugela River IFR Workshop* (26-30 September 1995, Montello Lodge): Starter Document. Department of Water Affairs and Forestry.
Hynes H.B.N. 1970. The ecology of running waters. Liverpool University Press. 555 pp. Illies J. and Botosaneanu L. 1963. Problemes et methodes de classification et de la zonation ecologique des eaux couramtes, considerees surtout du point de vue faunistique. *Mitt. int.Verein. theor. angew. Limnol*. **12:** 1-57.
King J.M. and Tharme R.E. 1994.Assessment of the instream flow incremental methodology and initial development of alternative instream flow methodologies for South Africa. Water Research Commission Report No 295/1/94. 590 pp.
McCafferty W.P. 1971. New burrowing mayflies from Africa (Ephemeroptera: Ephemeridae). *J. ent Soc. sth Afr* **34**(1): 57-62.
McCafferty W.P. and Gillies M.T. 1979. The African Ephemeridae (Ephemeroptera). *Aquatic Insects* **1**(3): 169-178.
McCafferty W.P. and de Moor F.C. 1995. South African Ephemeroptera: Problems and priorities. *In* Corkum L.D. and Ciborowski J.J.H. (eds) *Current direction in research on Ephemeroptera.* 463-476. Canadian Scholars' Press, Toronto.
Oliff W D, 1960a. Hydrobiological studies on the Tugela River System, Part I. The main Tugela River. *Hydrobiologia* **14**(3-4): 281-385.
Oliff W.D. 1960b. Hydrobiological studies on the Tugela River system. Part 2. Organic pollution in the Bushmans River. *Hydrobiologia* **16**: 137-196.
Oliff W D, 1964. Hydrobiological studies on the Tugela River System, Part IV. The Mooi River. *Hydrobiologia* **24**(4): 567-583.
Pinhey E.C.G. 1984. A survey of the dragonflies of South Africa: Part 1. Zygoptera. *Journal of the entomological Society of southern Africa* **47**(1): 147-188.
Pinhey E.C.G. 1985. A survey of the dragonflies of South Africa: Part 1. Anisoptera. *Journal of the entomological Society of southern Africa* **48**(1): 1-48.
Scott K.M.F. 1978. On the Hydropsychidae (Trichoptera) of southern Africa with keys to African genera of imagos, larvae and pupae and species lists. *Annals of the Cape Provincial Museums. (Natural History)* **14**: 299-422.
Skorozewski R. and F.C. de Moor 1999. Macroinvertebrate study. Task 2: Report Series. Consulting services for the establishment and monitoring of the instream flow requirements for river courses downstream of LHPW Dams. *LHDA Report* No. 648-17. 161pp.
Statzner B. Gore J.A. and Resh V.H. 1988. Hydraulic stream ecology: observed patterns and potential applications. *Journal of the North American Benthological Society* **7**(3):

307-360.

CREDENTIALS OF CONTRIBUTING SPECIALIST

Dr Ferdinand Cornelis de Moor (Ph.D Witwatersrand 1983). Aquatic Entomologist and ecologist. 25 years experience in research on freshwater aquatic ecosystems, 13 years experience in teaching and supervising undergraduate and graduate students at Rhodes University. Author or coauthor of more than 100 scientific publications, chapters in books and technical reports.

Table 1: Sampling stations and biotopes surveyed along the Bushmans and Tugela rivers during 1999

Site & Date	Description of site	Coordinates	Biotopes sampled
1. 4.X.99	Bushmans River at Riversdale	285540S 295843E	SIC, BRIC, MVIC, LIGHT
2. 17.VIII.99	Bushmans River above Weenen	285200S 300450E	SIC
3. 17.VIII.99	Bushmans River above Waterfall	284900S 301010E	SIC, POOL
4. 4.VIII.99	Bushmans River at Nkasini Bridge	284605S 300959E	SIC, MVIC, SAM
5. 3.X.99	Mahai River in RNNP	284118S 285638E	SOC, SIC, MVOC, LIGHT
6. 2.X.99	Tugela River at junction of Ingezungu River	284101S 285911E	SIC, ALGAE, FNW
7. 3.X.99	Tugela River below Rugged Glen Stables	284102S 290034E	SIC
8. 5.X.99	Tugela River at Khaisha farm corner	284419S 300836E	SIC, SOP
9. 18.VIII.99	Tugela River at Tugela Estates	284550S 300940E	SIC, MVIC, LIGHT
10. 17.VIII.99	Tugela River rapids	284430S 301350S	SIC, SOC, SED
11. 17.VIII.99	Tugela River upstream of Tugela Ferry	wrongly marked on map	SIC, BRIC
12. 5.X.99	Tugela River at Mbono downstream of Tugela Ferry	284531S 303224E	SIC, BRIC, LIGHT
13. 17.VIII.99	Tugela River at end of reach 7.2	284610S 305330E	SED, SOC, SIC
14. 6.X.99	Tugela River upstream of Jamesons Drift	284612S 305348E	SIC
15. 18.VIII.99 6.X.99	Tugela River at Mabula Trust farm downstream of Mamba River	285555S 310147E	SIC, MVIC, MVOC, SOC, LIGHT
16. 7.X.99	Mati River, tributary of Tugela River, at Mbulwini	290637S 310817E	SIC
17. 7.X.99	Tugela River at Emabhobhane Drift	290534S 311218E	SIC, BRIC, MVIC, MVOC
18. 7.X.99	Tugela River at Essiena Farm, Sunbury Estate near Mandini	290941S 312010E	SAND, MVIC, LIGHT

Table 2: Sampling stations and biotopes surveyed along the Bushmans and Tugela Rivers during 1985 by Mr B. K. Fowles

Site & date	Description of site	coordinates	Biotopes sampled
36. 7.VIII.1985	Little Bushmans River Stn B1 Sementdrif..	290103S 294705E	SED, MVIC
38. 7.VIII.1985	Little Busmans River Stn B10 below Nestle Factory	284500S 294500E	SED, MVIC
39. 7.VIII.1985	Bushmans River Stn B12 near Municipal Water works	290102S 295307E	MVIC, SED
40. 8.VIII.1985	Bushmans River Stn B16 downstream of sewage works	290042S 295439E	SED, MVIC
32. 31.VII.1985	Tugela River Stn 11at Cavern Road	283000S 294500E	MVIC, SIC
33. 31.VII.1985 2.VIII.1985	Tugela River Stn 10 at Hely Hutchinson Bridge	284353S 292147E	MVIC, MVIC, SED
35. 2.VIII.1985	Tugela River Stn 10A at Harts Hill	284202S 294950E	SIC, MVIC
41. 9.VIII.1985	Tugela River Stn 7 below Bushmans River	284430S 301330E	MVIC
45. 9.VIII.1985	Tugela River Stn 3A at Tugela Ferry	284459S 302634E	MVIC, SIC
47. 5.IX.1985	Tugela River Stn 2 at Nthsongweni	284342S 303913E	SED, SIC, SIC
48. 4.IX.1985	Tugela River Stn 1A at Middle Drift	285600S 310154E	SED, MVIC
49. 4.IX.1985	Tugela River Stn1 at Mandini	291015S 312336E	SED, MVIC

Table 3: Aquatic biotopes sampled during the 1985 and 1999 surveys

Biotope	Description
SED	Sediment sample
MVOC	Marginal vegetation out of current
MVIC	Marginal vegetation in current
SIC	Stones in the current
SOC	Stones out of the current
SAND	Sandy substratum
FNW	Flying near water
LIGHT	Light trap collecting at night
BRIC	Bedrock or boulders in current
POOL	Backwater pool or standing body of water
SAM	Submerged aquatic macrophytes
SOP	Surface of water in pool in river

Table 4. List of macroinvertebrate species obtained during various surveys of theTugela River catchment.

TAXA	Date of Survey		
	1953/ 1954	1985	1999
PORIFERA			
Fam. Gen. Sp. Indet.			*
TURBELLARIA			
Planariidae			
Dugesia sp.	*		
Planaria sp.		*	*
Dendrocoelidae			
Sorocelis **sp.**	*		
Microstomidae			
Microstomium sp.	*		
NEMERTEA			
Tertastemmatidae			
Prostoma sp.	*	*	*
NEMATODA			
Dorylaimidae			
Nygolaimus sp.	*		
Diplogasteridae			
Diplogaster sp. 1	*		
Diplogaster sp. 2	*		
Mermithidae			
Gen. sp. indet.	*	*	*
NEMATOMORPHA			
Parachordodidae			
Paragordius sp.			*
ANNELIDA			

TAXA	Date of Survey		
	1953/ 1954	1985	1999
HIRUDINEA			
Glossiphoniidae			
Glossiphonia sp.?	*		
Salifa ?perspicax		*	
Helobdella sp.	*		
Gen. sp. indet.		*	*
OLIGOCHAETA			
Aeolosomatidae			
Aelosoma beddardi?	*		
Naididae			
Chaetogaster sp.	*		
Nais spp.	*	*	*
Stylaria sp.	*		
Slavina sp.	*		
Dero limosa?	*		
Aulophorus furcatus?	*		
Naidium sp.	*		
Pristina sp.	*		
Gen. sp. Indet.		*	
Lumbriculidae			
Gen. sp. indet.	*		*
Tubificidae			
Tubifex sp.	*	*	
Branchiura sowerbyi	*	*	
Limnodrilus sp.	*		
Gen. Sp. Indet.		*	*
MOLLUSCA			
GASTROPODA			
Planorbidae			

TAXA	Date of Survey		
	1953/ 1954	1985	1999
Bulinus tropicus			*
Bulinus natalensis		*	
Bulinus spp.		*	*
Gyraulus sp.		*	
Biomphalaria pfeifferi		*	
Biomphalaria sp.			*
Physidae			
Physa acuta		*	*
Lymnaeidae			
Gen. sp. Indet.		*	
Ancylidae			
Burnupia spp.		*	*
PELECYPODA			
Sphaeriidae			
Pisidium spp.		*	*
Corbiculidae			
Corbicula sp.		*	*
Corbicula fluminalis			*
CRUSTACEA			
CLADOCERA			
Daphniidae			
Daphnia pulex	*		
Daphnia spp.	*	*	
Simocephalus capensis	*		
Simocephalus vetuloides	*		
Simocephalus sp.	*		
Ceriodaphnia quadrangula	*		
Ceriodaphnia cf. pulchella	*		

TAXA	Date of Survey		
	1953/ 1954	1985	1999
Moina propinqua?	*		
Bosminidae			
Bosmina longirostris?	*		
Macrothricidae			
Macrothrix propinqua	*		
Ilyocryptus sordidus	*		
Ilyocryptus sp.		*	
Chydoridae			
Leydigia cf. microps	*		
Leydigia cf. quadrangularis	*		
Alona cf. affinis	*		
Alona cambouei	*		
Alona cf. gutatta	*		
Alona striolata	*		
Alona rectangula	*		
Chydorus gibsoni	*		
Chydorus sphaericus	*		
Chydorus sp.		*	
Gen. sp. indet.		*	*
COPEPODA			
Diapotomidae			
Tropodiaptomus spectabilis	*		
Paradiaptomus lammelatus	*		
Cyclopidae			
Cyclops sp.		*	
Macrocyclops albidus	*		
Tropocyclops confinis	*		
Ectocyclops hirsutus	*		
Eucyclops eucanthus	*		

TAXA	Date of Survey		
	1953/ 1954	1985	1999
Eucyclops cf. gibsoni	*		
Eucyclops cf. sublaevis	*		
Eucyclops cf. speratus	*		
Paracyclops cf. affinis	*		
Paracyclops fimbriatus	*		
Paracyclops poppei	*		
Mesocyclops leuckarti	*		
Mesocyclops cf. hyalinus	*		
Thermocyclops schuurmanae	*		
Canthocamptidae		*	*
Elaphoidella bidens	*		
Harpactiocus sp.	*		
Fam. Gen. sp. Indet.		*	*
OSTRACODA			
Cyprididae			
Ilyocypris australiensis	*		
Isocypris priomena	*		
Isocypris sp.	*		
Cypria capensis	*		
Eucypris sp.	*		
Herpetocypris chevreuxi	*		
Cypridopsis gregaria	*		
Cypridopsis hirsuta	*		
Cypridopsis glabrata	*		
Cypridopsis reniformis	*		
Cypretta arcuata	*		
Cypretta minna	*		
Typhalocypris sp.	*		

TAXA	Date of Survey		
	1953/ 1954	1985	1999
Eucypris sp	*		
Zonocypris cordata?	*		
Zonocypris tuberae?	*		
Limnothricidae			
Gomphocythere sp.?		*	
Fam. Gen. spp. indet.		*	*
MALOCOSTRACA			
Mysidacea			
Gastrosaccus brevifissura	*		
Tanaidae			
Tanais annectens	*		
Tanais philetaerus	*		
ISOPODA			
Jaeridae			
Protojarina perbrincki	*		
Eurydicidae			
Pontogeloides latipes	*		
AMPHIPODA			
Gammaridae			
Crangonyx robertsii	*		
Talitridae			
Talorchestia sp.	*		
Orchestia sp.	*		
Corophilidae			
Corophium triaenonyx?	*		
Aoridae			
Grandidierella cf. bonnieri	*		
DECAPODA			
Grapsidae			

TAXA	Date of Survey		
	1953/ 1954	1985	1999
Serarma catenta	*		
Serarma eulimene	*		
Potamonidae			
Potamonautes sidneyi	*		
Potamonautes dubius	*		
Potamonautes warreni	*		
Potamonautes perlatus	*		
Upogebiidae			
Upogebia africana	*		
Penaeidae			
Penaeus monodon	*		
Penaeus japonicus	*		
Metapenaeus monoceros	*		
Atyidae			
Caridina africana		*	
Caridina typus	*		
Caridina nilotica var. natalensis	*		*
Palaemonidae			
Macrobrachium cf. idella	*		
Macrobrachium equidens	*		
Macrobrachium lepidactylus	*		
Macrobrachium vollenhoveni?			*
Palaemon pacificus	*		
COLLEMBOLA			
Poduridae			
Gen. spp. indet.		*	*
ARACHNIDA			
ARANAEIDA			

TAXA	Date of Survey		
	1953/ 1954	1985	1999
Fam. Gen. sp. indet.			*
Tetragnathidae			
Tetragnatha sp.		*	*
Lycosidae			
Gen. sp. Indet.		*	
HYDRACARINA			
Fam. Gen. spp. indet.		*	*
INSECTA			
EPHEMEROPTERA			
Baetidae			
Acanthiops varius	*		
Acanthiops tsitsa			*
Afroptilum sudafricanum	*	*	*
Afroptilum parvum	*		
?*Afroptilum* spp.	*		
Baetis cataractae	*		
Baetis harrisoni	*	*	*
Baetis lawrencei	*		
Baetis parvulus?	*		
Baetis sp. 1.	*		
Baetis sp. 2	*		
Centroptiloides bifasciata	*	*	*
Cloeon africanum	*		*
Cloeon virgiliae	*		
Cloeon sp.		*	*
Cloeodes inzingae	*		
Crassabwa flava			*
Cheleocloeon excisum	*	*	*
Dabulamainzia helenae		*	

TAXA	Date of Survey		
	1953/ 1954	1985	1999
Dabulamanzia indusii	*		
Dabulamanzia media	*		
Demoreptus capensis			*
Demoreptus natalensis	*		*
Demoreptus monticola	*		
Potamocloeon macafertiorum			*
Pseudocloeon aquacidus		*	
Pseudocloeon bellum	*		
Pseudocloeon glaucum	*	*	*
Pseudocloeon piscis		*	*
Pseudocloeon vinosum	*	*	*
Pseudocloeon sp.nov?		*	*
Pseudopannota maculosa	*	*	
Caenidae			
Caenis capensis	*		
Caenis sp. 2			*
Caenis sp. 3		*	*
Caenis sp. 5		*	*
Caenis sp. 6			*
Caenis spp. indet.	*	*	*
Clypeocaenis umgeni		*	*
Heptageniidae			
Afronurus harrisoni	*		
Afronurus peringueyi	*	*	*
Afronurus sp.	*		*
Compsoneuriella bequaerti			*
Leptophlebiidae			
Aprionyx tricuspidatus	*		

TAXA	Date of Survey		
	1953/ 1954	1985	1999
Adenophlebia auriculata	*		
Adenophlebia sylvatica	*		
Castanophlebia calida	*		
Euthraulus elegans	*	*	*
Tricorythidae			
Tricorythus discolor	*		*
Tricorythus reticulatus	*	*	*
Tricorythus "lowveld"		*	
Polymitarcyidae			
Ephoron savignyi	*		*
Ephemeridae			
Eatonica schoutedini	*		
Oligoneuriidae			
Elassoneuria trimeniana	*		*
Oligoneuropsis lawrencei	*		
Prosopistomatidae			
Prosopistoma crassi	*	*	*
Prosopistoma sp.	*		
PLECOPTERA			
Perlidae			
Neoperla spio	*	*	*
ODONATA			
Chlorolestidae			
Chlorolestes fasciata	*		
Chlorolestes tesselatus	*		
Chlorolestes longicauda	*		
Lestidae			
Lestes plagiatus	*		

TAXA	Date of Survey		
	1953/ 1954	1985	1999
Calopterygidae			
Phaon iridipennis	*		
Chlorocyphidae			
Platycypha caligata	*		
Chlorocypha fitzsimonsi	*		
Chlorocypha spp.			
Platycnemididae			
Allocnemis leucosticta	*		
Coenagrionidae			
Ceriagrion glabrum	*		
Ceriagrion sp.		*	
Pseudagrion acaciae	*		
Pseudagrion citricola	*		
Pseudagrion glaucescens	*		
Pseudagrion kersteni	*		
Pseudagrion makabusiensis	*		
Pseudagrion natalense	*		
Pseudagrion pseudomassaicum	*		
Pseudagrion salisburyense	*		
Pseudagrion sjostedti	*		
Pseudagrion spp.		*	*
Enallagma elongatum			
Enallagma glaucum	*		
Agriocnemis exilis	*		
Gomphidae			
Notogomphus praetorius	*		
Notogomphus sp.		*	
Paragomphus cognatus	*		
Paragomphus hageni	*		

TAXA	Date of Survey		
	1953/ 1954	1985	1999
Paragomphus spp.	*	*	*
Ceratogomphus pictus			
Corduliidae			
Macromia sp.			*
Syncordulia sp.?		*	*
Libellulidae			
Tetrathemis polleni	*		
Orthetrum brachiale	*		
Orthetrum caffrum	*		
Orthetrum crysostigma	*		
Orthetrum farinosum	*		
Orthetrum stemmale	*		
Palpopleura juncunda	*		
Palpopleura lucida	*		
Hemistigmata albipuncta	*		
Diplacodes lefebvrei	*		
Crocothemis erythraea	*		
Crocothemis sanguinolenta	*		
Brachythemis leucosticta	*		
Philonomon luminans	*		
Sympetrum fonscolombei	*		
Trithemis annulata	*		
Trithemis arteriosa	*		
Trithemis dorsalis	*		
Trithemis kerbyi	*		
Trithemis risi	*		
Trithemis stricta	*		

TAXA	Date of Survey		
	1953/ 1954	1985	1999
Trithemis sp.		*	*
Zygonyz natalensis	*		
Zygonyx torrida	*		
Zygonyx sp.		*	*
Rhyothemis semihyalina	*		
Pantala flavescens	*		
Aeshnidae			
Aeshna subpupilata			*
Aeshna miniscula	*		*
Aeshna sp.		*	
Anaciaeschna triangulfiera	*		
Anax speratus	*		
HEMIPTERA			
Belostomatidae			
Sphaerodema nepoides	*		
Gerridae			
Gerris hypoleuca	*		
Gerris swakopensis	*		
Gerris sp.			
Gen. sp. indet.			
Nepidae			
Nepa cf. cinerea	*		
Ranatra cf. linearis	*		
Ranatra sp.		*	*
Veliidae			
Rhagovelia nigricans	*		
Rhagovelia sp.		*	*
Microvelia major	*		

TAXA	Date of Survey		
	1953/ 1954	1985	1999
Microvelia sp.?			*
Gen. sp. indet.			*
Hydrometridae			
Hydrometra stagnorum	*		
Mesoveliidae			
Mesovelia sp.		*	*
Pleidae			
Plea pullula	*		
Plea picanina	*		*
Naucoridae			
Aphelocheirus schoutedeni	*		
Macrocoris flavicollis	*		
Laccocoris limnigenus	*		
Laccocoris sp.		*	*
Gen. sp. indet.			*
Notonectidae			
Enithares ?chinai	*		
Enithares sobria	*		
Enithares sp.	*		
Enithares v. flavum	*		
Anisops cf. aglaia	*		
Anisops debilis	*		
Anisops gracilis	*		
Anisops gracilliodes	*		
Nychia limpida limpida	*		
Gen. sp. indet.			*
Corixidae			
Micronecta hessi	*		
Micronecta scutellaris	*		

TAXA	Date of Survey		
	1953/ 1954	1985	1999
Micronecta piccanin	*		
Micronecta spp.		*	*
Sigara sjostedti	*		
Sigara sp.			
Aphididae			
Gen. sp. indet.		*	*
Helotrephidae			
Naboandelus sp.	*		
Ochterus marginitus	*		
NEUROPTERA			
Sisyridae			
Sisyra sp.			*
TRICHOPTERA			
Leptoceridae			
Adicella sp.	*		
Leptocerus sp.	*		
Athripsodes corniculans		*	*
Athripsodes harrisoni	*		
Athripsodes fissus	*		
Oecetis modesta	*		
Oecetis sp.			*
Leptocerina sp.	*		
Ceraclea (Pseudoleptocerus) sp.			*
Trianodes sp.			*
Trichosetodes angssa			*
New genus			*
Hydropsychidae			
Cheumatopsyche afra	*	*	*

TAXA	Date of Survey		
	1953/ 1954	1985	1999
Cheumatopsyche thomasseti	*	*	
Cheumatopsyche falcifera	*		*
Cheumatopsyche triangularis	*		
Cheumatopsyche maculata	*		
Cheumatopsyche "type 10"		*	
Cheumatopsyche "type 9"		*	*
Cheumatopsyche "type 5"			*
Cheumatopsyche "type 2"		*	*
Amphipsyche scottae		*	
Hydropsyche ulmeri	*		
Hydropsyche longifurca	*	*	*
Polymorphanisus bipunctatus	*		
Polycentropodidae			
Polyplectropus sp.	*		
Pseudoneurecilpsis sp	*		
Ecnomidae			
Ecnomus thomasseti	*		*
Ecnomus natalensis	*		
Ecnomus spp.	*		*
Psychomyidae			
Lype sp.	*		
Pauduniella sp.	*		
Philopotamidae			
Chimarra sp.	*		
Hydroptilidae			
Hydroptila cruciata	*	*	*
Oxyethira sp.			*
Orthotrichia barnardi		*	*
Dipseudopsidae			

TAXA	Date of Survey		
	1953/ 1954	1985	1999
Dipseudopsis capensis			*
LEPIDOPTERA			
Pyralidae			
Nymphula sp.			*
Petrophila sp.			*
?*Paraponyx* sp.		*	
Gen. Sp. Indet			*
COLEOPTERA			
Dytiscidae			
Amarodytes peringueyi	*		
Bidessus sharpi	*		
Canthydrus nigerrimus	*		
Canthydrus quadrivittatus	*		
Canthydrus sedilloyi	*		
Clypeodytes coaarcticallis	*		
Clypeodytes meridionalis	*		
Copelatus polystrigus	*		
Guignotus harrisoni	*		
Hydaticus servillianus	*		
Hydrovatus validicornis	*		
Hydroporus sp.		*	
Hyphydrus aethiopicus	*		
Hyphydrus? caffer	*		
Laccophilus adspersus	*		
Laccophilus amphlicatus	*		
Laccophilus congener	*		
Laccophilus continentalis	*		
Laccophilus cyclopis	*		

TAXA	Date of Survey		
	1953/ 1954	1985	1999
Laccophilus lineatus	*		
Laccophilus olsoneffi	*		
Laccophilus pilitaris	*		
Laccophilus sp.	*		
Philaccolus lineatoguttatus	*		
Neptosternus ornatus	*		
Potamonectes vagrans	*		
Yola natalenisi	*		
Yola subopaca	*		
Yola tuberculata	*		
Gen. indet. sp.1			*
Gen. indet. sp.2			*
Gyrinidae			
Aulonogyrus abdominalis	*		
Aulonogyrus amoenulus	*		
Aulonogyrus alternatus	*		*
Aulonogyrus sesotho	*		
Aulonogyrus spp.		*	*
Dinutes aerus	*		
Gyrinus natalensis	*		
Orectogyrus conformis	*		
Orectogyrus oscari	*		
Orectogyrus polli	*		
Orectogyrus sp.		*	
Coccinelidae			
Scymus ?fallax	*		
Nephus ?augustus	*		
Hydrophilidae			
Berosus australis		*	

TAXA	Date of Survey		
	1953/ 1954	1985	1999
Gen. sp. indet.			*
Hydraenidae			
Ochthebius sp.		*	
Hydraena sp.		*	
Gen. spp. indet.		*	*
Curculionidae			
Baris sp.	*		
Coeliodes celastri	*		
Piezotrachelus magnirostris	*		
Elmidae			
Potamodytes sp.			*
Gen. spp. indet.		*	*
Chrysomelidae			
Melosoma discolor	*		
Halticidae			
Haltica cuprea	*		
Aphthona marshalli	*		
Galerucidae			
Estcourtiana litura	*		
Staphylinidae			
Gen. sp. indet.		*	
DIPTERA			
Blepharoceridae			
Elporia flavopicta	*		
Elporia hiemis	*		
Elporia natalensis	*		
Elporia scruposa	*		
Psychodidae			

TAXA	Date of Survey		
	1953/ 1954	1985	1999
Psychoda alternata	*		
Psychoda dentata	*		
Psychoda sp.		*	
Telmatoscopus sp.	*		
Dixidae			
Dixa bicolor	*		
Chaoboridae			
Chaeoborus microstictus	*		
Culicidae			
Anopheles ardensus	*		
Anopheles cinereus	*		
Anopheles demeilloni	*		
Anopheles listeri	*		
Culex andersoni subsp. bwambanus	*		
Culex salisburiensis	*		
Culex tigripes	*		
Culex univittatus	*		
Culex vansomereni	*		
Theobaldia longiareolata	*		
Anopheles sp.	*		
Simuliidae			
Simulium nigritarse	*		
Simulium bovis	*	*	*
Simulium damnosum s.l.	*	*	*
Simulium cervicornutum			*
Simulium rotundum	*		
Simulium medusaeforme	*	*	*
Simulium vorax		*	*

TAXA	Date of Survey		
	1953/ 1954	1985	1999
Simulium mcmahoni		*	*
Simulium hargreavesi			*
Simulium dentulosum	*		
Simulium impukane		*	*
Simulium debegene	*		
Simulium adersi		*	*
Simulium spp.		*	
Chironomidae			
Tanypodinae			
Pentaneura appendiculatus	*		
Pentaneura cornata	*		
Pentaneura cygnus	*		
Pentaneura dusoleli	*		
Pentaneura nigromarmorata	*		
Pentaneura palpalis	*		
Pentaneura tinctoria	*		
Pentaneura sp. nov.	*		
Pentaneura trifascia	*		
Pentaneura spp.		*	*
Tanypus lacustris	*		
Gen. sp. indet.		*	*
Orthocladiinae			
Corynoneura spp.	*	*	*
Metriocnemis dewulfi	*		
Metriocnemis scotti	*		
Cardiocladius latistilus	*		
Cardiocladius oliffi	*		
Cricotopus albitibia	*		
Cricotopus bizonatus	*		

TAXA	Date of Survey		
	1953/ 1954	1985	1999
Crictopus bergensis	*		
Crictopus harrisoni	*		
Cricotopus obscurus	*		
Cricotopus scottae	*		
Cricotopus sp. nov..	*		
Orthocladius bergensis	*		
Orthocladius lobiger	*		
Procladius brevipetiolatus	*		
Pseudorthocladius similis	*		
Chaetocladius excerptus	*		
Nanocladius vitellinus	*		
Nanocladius ephippium	*		
Nanocladius niveipluma	*		
Limnophyes spinosa	*		
Trichocladius capensis	*		
Trichocladius micans	*		
Pseudosmittia conigera	*		
Thienemanniella sp.?		*	
Gen. spp. indet.		*	*
Chironominae			
Chironomini			
Chironomus albomarginatus	*		
Chironomus biclavatus	*		
Chironomus caffrarius	*		
Chironomus lindneri	*		
Chironomus pulcher	*		
Chironomus reductus	*		
Chironomus forcipatus	*		

TAXA	Date of Survey		
	1953/ 1954	1985	1999
Chironomus monilis	*		
Chironomus palustris	*		
Microtendipes lentiginosus	*		
Microtendipes taitae	*		
Polypedilum kibatiense	*		
Polypedilum scotti	*		
Polypedilum natalensis	*		
Polypedilum pruina	*		
Polypedilum tridens	*		
Polypedilum alticola	*		
Polypedilum quinqueguttatatum	*		
Stictochironomus festivus	*		
Cryptochironomus coronatus	*		
Stempellina truncata	*		
? *Xenochironomus* sp.			*
Gen. sp. indet.		*	*
Tanytarsini			
Cladotanytarsus pseudomancus	*		
Tanytarsus furcus	*		
Tanytarsus nigricornis	*		
Tanytarsus sp.	*	*	
Rheotanytarsus spp.		*	*
Gen. sp. indet.		*	*
Ceratopogonidae			
Atrichopogon hirsutipennis	*		
Atrichopogon sp.	*		
Bezzia pistiae	*		
Bezzia sp.		*	*
Brachypogon sp.	*		

TAXA	Date of Survey		
	1953/ 1954	1985	1999
Ceratopogon sp. nov.	*		
Dasyhelea fusca.	*		
Dasyhelea sp.	*	*	
Lasiohelea sp.	*		
Palpomyia oliffi	*		
Gen. sp. indet.		*	*
Empididae			
Wiedemannia sp.			*
Gen. sp. indet.		*	
Tabanidae			
Gen. sp. indet.		*	*
Tipulidae			
Antocha sp.			*
Muscidae			
Limnophora sp.		*	*
Gen. sp. indet.		*	*

Table 5: List of macroinvertebrate species obtained during various surveys of the Bushmans and Little Bushmans Rivers.

TAXA	Date of Survey			
	1960	1967	1985	1999
PORIFERA				
Fam. Gen. Sp. Indet.				*
CNIDARIA				
Hydridae				
Hydra sp. 1	*			
Hydra sp. 2	*			
TURBELLARIA				
Planariidae		*		
Dugesia sp.	*			
Planaria sp.	*			
Gen. sp. indet.			*	*
Dendrocoelidae				
Sorocelis sp.	*	*		
Microstomidae				
Microstomium sp.	*	*		
NEMATODA				
Dorylaimidae				
Nygolaimus sp.	*			
Diplogasteridae				
Diplogaster sp.	*			
Mermithidae				
Gen. sp. indet.		*	*	
TARDIGRADA				
Tardigrada sp. 1	*			
ANNELIDA				

TAXA	Date of Survey			
	1960	1967	1985	1999
HIRUDINEA				
Glossiphoniidae				
Glossiphonia sp.	*			
Gen. sp. indet.			*	*
OLIGOCHAETA				
Aeolosomatidae				
Aelosoma beddardi?	*			
Naididae				
Chaetogaster sp.	*	*		
Nais sp. 1	*	*		
Nais sp. 2	*			
Nais spp.	*		*	
Stylaria sp.	*			
Dero limosa?	*			
Aulophorus furcatus	*			
Naidium sp.	*			
Pristina sp.	*	*		
Gen. sp. Indet.			*	*
Lumbriculidae				
Lumbriculidae sp. 1	*			
Tubificidae				
Tubifex sp.	*	*	*	
Branchiura sowerbyi	*			
Limnodrilus sp.	*	*		
Gen. Sp. Indet.			*	
MOLLUSCA				
GASTROPODA				
Planorbidae				

TAXA	Date of Survey			
	1960	1967	1985	1999
Planorbia anderssoni	*			
Ancylidae				
Burnupia gordonensis	*			
Burnupia ponsonbyi	*			
Burnupia spp.				*
Ferrissia sp.	*			
Ferrissia burnupi	*			
PELECYPODA				
Sphaeriidae				
Pisidium spp.	*	*		
CRUSTACEA				
CLADOCERA				
Daphniidae				
Simocephalus capensis	*			
Simocephalus vetuloides	*	*		
Ceriodaphnia quadrangula	*	*		
Ceriodaphnia cf. pulchella	*			
Moina propinqua?	*			
Bosminidae				
Bosmina longirostris	*			
Macrothricidae				
Macrothrix propinqua	*			
Ilyocryptus sordidus	*			
Chydoridae				
Leydigia microps	*			
Leydigia cf. quadrangularis	*			
Alona cf. affinis	*			
Alona cambouei	*			
Alona costale		*		

TAXA	Date of Survey			
	1960	1967	1985	1999
Alona gutatta	*	*		
Alona striolata	*			
Chydorus gibsoni	*	*		
Pleuroxus aduncus	*			
Pleuroxus assimilis		*		
Gen. sp. indet.			*	
COPEPODA				
Ameiridae				
Nitocra dubia		*		
Cyclopidae				
Cyclops ?agilis		*		
Cyclops albidus		*		
Cyclops ?sublaevis		*		
Cyclops fibriatus poppyi		*		
Cyclops prasinus		*		
Cyclops sp.			*	
Macrocyclops albidus	*			
Tropocyclops confinis	*			
Elaphoidella bidens	*			
Eucyclops eucanthus	*			
Eucyclops cf. sublaevis	*			
Eucyclops cf. speratus	*			
Paracyclops fimbriatus	*			
Paracyclops poppei	*			
Mesocyclops leuckarti	*			
Thermocyclops schuurmanae	*			
Fam. Gen. sp. Indet.			*	
OSTRACODA				

TAXA	Date of Survey			
	1960	1967	1985	1999
Cyprididae				
Ilyocypris australiensis	*			
Cypria capensis	*			
Cyprilla arcuata	*			
Eucypris sp.	*	*		
Herpetocypris chevreuxi	*			
Cypridopsis hirsuta	*			
Cypridopsis reniformis	*	*		
Cypretta arcuata	*			
Cypretta minna	*			
Cypretta sp.		*		
Zonocypris sp.	*			
Fam. Gen. spp. indet.			*	
DECAPODA				
Potamonidae				
Potamonautes sidneyi	*	*		
COLLEMBOLA				
Entomobryidae				*
ARACHNIDA				
ARANAEIDA				
Fam. gen. sp. indet.			*	
HYDRACARINA				
Fam. Gen. spp. indet.	*		*	*
INSECTA				
EPHEMEROPTERA				
Baetidae				
Afroptilum sudafricanum	*			
Afroptilum parvum	*			

TAXA	Date of Survey			
	1960	1967	1985	1999
?Afroptilum spp.	*			
Baetis harrisoni	*	*	*	*
Baetis sp. 1	*			
Baetis sp. 2	*			
Cloeon africanum	*	*		
Cloeon virgiliae	*	*	*	*
Cloeodes inzingae			*	
Cheleocloeon excisum	*	*	*	*
Dabulamanzia indusii	*			
Dabulamanzia media				*
Demoulinia crassi			*	
Pseudocloeon aquacidum			*	
Pseudocloeon bellum	*	*		
Pseudocloeon glaucum		*		*
Pseudocloeon vinosum	*	*		
Pseudocloeon sp.nov?			*	
Pseudopannota maculosa	*			
Caenidae				
Caenis capensis	*	*		
Caenis sp. 2			*	*
Caenis sp. 3			*	
Caenis spp. indet.	*	*		
Clypeocaenis umgeni				*
Heptageniidae				
Afronurus peringueyi				*
Afronurus sp.	*			
Leptophlebiidae				
Adenophlebia auriculata	*			
Euthraulus elegans	*	*		*

TAXA	Date of Survey			
	1960	1967	1985	1999
Tricorythidae				
Tricorythus discolor	*			*
Prosopistomatidae				
Prosopistoma crassi	*			*
PLECOPTERA				
Perlidae				
Neoperla spio				*
ODONATA				
Lestidae				
Lestes plagiatus	*			
Chlorocyphidae				
Chlorocypha spp.	*			
Coenagrionidae				
Pseudagrion natalense	*			
Pseudagrion salisburyense	*	*		
Pseudagrion spp.		*	*	
Gomphidae				
Paragomphus cognatus	*			
Libellulidae				
Trithemis sp.	*	*	*	
Zygonyx sp.	*			
Aeshnidae				
Aeshna rileyi	*			
HEMIPTERA				
Veliidae				
Rhagovelia nigricans	*			
Microvelia sp.		*		
Pleidae				

TAXA	Date of Survey			
	1960	1967	1985	1999
Plea pullula	*			
Naucoridae				
Laccocoris limnigenus	*			
Notonectidae				
Enithares sobria	*			
Anisops varia	*			
Gen. sp. indet.		*	*	
Corixidae				
Micronecta piccanin	*			
Micronecta spp.			*	
NEUROPTERA				
Sisyridae				
Sisyra ?afra.				*
TRICHOPTERA				
Leptoceridae				
Leptocerus sp.		*		
Athripsodes bergensis gp.			*	
Athripsodes harrisoni	*	*		*
Oecetis sp.			*	
Trichosetodes sp.				*
Triaenodes sp. 1				*
Triaenodes sp. 2				*
Genus and sp. Nov.				*
Hydropsychidae				
Cheumatopsyche thomasseti	*			
Cheumatopsyche triangularis	*			
Cheumatopsyche maculata	*			
Cheumatopsyche falcifera				*

TAXA	Date of Survey			
	1960	1967	1985	1999
Cheumatopsyche "type 2"				*
Cheumatopsyche sp. indet.	*			
Hydropsyche ulmeri	*			
Hydropsyche longifurca				*
Macrostemum capense				*
Polycentropodidae				
Paranyctiophylax sp.			*	
Ecnomidae				
Ecnomus spp.	*		*	
Hydroptilidae				
Hydroptila cruciata	*			*
Hydroptila sp.	*			
Dipseudopsidae				
Dipseudopsis sp.	*			
LEPIDOPTERA				
Pyralidae				
Nymphula sp.	*			
COLEOPTERA				
Dytiscidae				
Guignotus harrisoni	*			
Hydaticus sp.		*		
Hydroporus sp.		*		
Laccophilus lineatus	*			
Potamonectes vagrans	*			
Gen. spp. indet.		*		
Gyrinidae				
Aulonogyrus abdominalis	*			
Aulonogyrus sesotho	*			

TAXA	Date of Survey			
	1960	1967	1985	1999
Gyrinus natalensis	*			
Gen. spp. indet.	*	*		*
Hydrophilidae				
Berosus sp.	*	*		
Hydroporus sp.	*			
Gen. sp. indet.		*	*	
Psephenidae				
Eubrianax sp.	*			
Hydroscaphidae				
Gen sp. indet.	*			
Hydraenidae				
Ochthebius spp.	*	*		
Gen. spp. indet.			*	
Elmidae				
Gen. spp. indet.	*	*	*	*
DIPTERA				
Blepharoceridae				
Elporia flavopicta	*			
Psychodidae				
Pericoma sp.	*			
Psychoda alternata	*			
Dixidae				
Dixa sp.	*			
Culicidae				
Anopheles spp.	*	*		
Culex spp.	*	*		
Simuliidae				
Simulium nigritarse	*		*	*
Simulium damnosum s.l.				*

TAXA	Date of Survey			
	1960	1967	1985	1999
Simulium cervicornutum				*
Simulium rotundum	*			*
Simulium medusaeforme	*			*
Simulium vorax				*
Simulium mcmahoni				*
Simulium hargreavesi				*
Simulium adersi				*
Simulium schoutedeni	*			
Simulium wellmani				*
Simulium lumbwanum				*
Simulium spp.	*			
Chironomidae				
Tanypodinae				
Pentaneura spp..	*	*		
Tanypus sp.		*		
Gen. spp. indet.			*	*
Orthocladiinae				
Corynoneura spp.		*		*
Procladius sp. 1	*			
Procladius sp. 2	*			
Orthocladiinae spp	*			
Gen. spp. indet.	*		*	*
Chironominae				
Chironominae spp.	*			
Chironomini				
Gen. sp. indet.	*		*	*
Tanytarsini				
Tanytarsus sp.	*			

TAXA	Date of Survey			
	1960	1967	1985	1999
Rheotanytarsus spp.	*			*
Gen. sp. indet.			*	*
Ceratopogonidae				
Ceratopogonidae sp.	*			
Gen. sp. indet.	*	*		
Empididae				
Argyra sp.	*			
Hemerodromia sp.	*			
Athericidae				
Atherix sp.	*			*
Tabanidae				
Haemapota sp.	*			
Tipulidae				
Antocha sp.			*	
Gen. sp. indet.	*		*	
Muscidae				
Limnophora sp.	*			

Table 6: Record of Ephemeroptera along different zones in the Tugela River as proposed by Oliff 1960a

Species	Dates of surveys		
	1953/55	1985	1999
Prosopistomatidae			
Prosopistoma crassi	5,6	7	7
Polymitarcyidae			
Ephoron savigni	5		
Ephemeridae			
Eatonica schoutedeni	5		
Oligoneuriidae			
Oligoneuropsis lawrenci	3		
Elassoneuria trimeniana	5,7		5
Baetidae			
Cloeon africanum	5		6
Cloeon virgiliae	4,5,6,7		
Cloeodes inzingae	3,4,5,6,7		
Pseudopannota maculosa	4,5	7	
Pseudocloeon vinosum	4,5,6,7	5,7	6,7
Pseudocloeon bellum	4,5,6,7		
Pseudocloeon glaucum	5,6,7	7	6,7
Pseudocloeon aquacidum		4,6	
Pseudocloeon piscis		7	7
Baetis harrisoni	3,4,5,6,7	4,5,6,7	4,6,7
Baetis cataractae	3		
Baetis lawrenci	1		
Baetis parvulus?	3,4		
Demoreptus natalensis	1,2,3,4		4
Demoreptus capensis			4
Demoreptus monticola	3		
Afroptilum parvum	3,4		
Afroptilum sudafricanum	1,2,3,4	4	4
Cheleocloeon excisum	4,5,6,7	4,5,6	6,7
Centroptiloides bifasciata	6,7	5,6,7	6,7
Crassabwa flava			7
Dabulamanzia media	5,6,7		
Dabulamanzia helenae		5	
Dabulamanzia indusii	5,6,7		
Acanthiops varium	4,5,6		
Acanthiops tsitsa			7
Potamocloeon macafertiorum			6
Caenidae			
Caenis capensis	1,2,3,4,5,6,7		
Caenis spp.			4,6,7
Clypeocaenis umgeni		6,7	6,7
Tricorythidae			
Tricorythus discolor	3,4,5,6,7		7
Tricorythus reticulatus	5	7	4,7
Tricorythus "lowveld"		4,5,7	
Leptophlebiidae			

Aprionyx tricuspidatus	3		
Adenophlebia auriculata	1,2,3,4		
Adenophlebia sylvatica	3		
Castanophlebia calida	3		
Euthraulus elegans	3,4,5,6,7	6,7	4,6,7
Heptageniidae			
Afronurus peringueyi	4	5,6,7	4,6,7
Compsoneuriella bequaerti	5,6,7		6

Table 7: Comparison of trichopteran species distribution along the zones suggested by Oliff (1960a) for the 1953/54 Oliff survey, 1985 Fowles survey and 1999 (present survey).

Species	Dates of surveys		
	1953/1955	1985	1999
Leptoceridae *Adicella* sp	5		-
Leptocerus sp.	6		-
Athripsodes corniculans	-	7	7
A. harrisoni	4,5	-	-
A. fissus	4	-	-
Oecetis sp.	5,6	5,6,7	6
Leptocerina sp.	5,6,7	-	-
Ceraclea (Pseudoleptocerus) sp.	-	-	6
Triaenodes sp.	-	-	6
Trichosetodes angssa	-	-	6
Leptoceridae (new genus)	-	-	6,7
Hydropsychidae *Cheumotopsyche afra*	6	5	4
C. thomasseti	4,5,6,7	5	
C. falcifern	7	-	6,7
C. triangularis	4,5,6		
C. maculata	3,4		
Cheumatopsyche "Type 10"		6	
C. "Type 9"		5,6,7	6,7
C. "Type 5"			4
C. "Type 2"		6,7	6,7
Amphipsyche scottae		5	
Hydropsyche ulmeri	3,4,5,6,7		
H. longifurca	6,7	5	4,6
Polymorphanisus bipunctatus	5-6		
Polycentropodidae *Polyplectropus*	4		
Pseudoneureclipsis	4,5		
Ecnomidae *Ecnomus thomasseti*	4		7

E. natalensis	4		

Table 7 (cont.)

Species	1953/1955	1985	1999
Ecnomus spp.	3,4,5		6
Psychomyidae *Lype* sp.	3		
Paduniella ankya	4		
Philopotamidae *Chimarra* sp.	4		
Hydroptilidae *Hydroptila cruciata*	1,2,3,4,5,6,7	5,6,7	6,7
Oxyethira sp.			7
Orthotrichia barnardi		6,7	7
Dipseudopsidae *Dipseudopsis capensis*			7

Table 8: Comparison of simuliid species distribution along the zones suggested by Oliff (1960a) for the 1953/54 Oliff survey, 1985 Fowles survey and 1999 (present survey).

Species	Dates of surveys		
	1953/55	1985	1999
Simulium bovis	6,7	6,7**	6,7
S. wellmani	-	5	4
S. vorax	-	6	7
S. medusaeforme	1-6	5,7	4,6,7
S. hargreavesi	-	-	-
S. mcmahoni	-	5,6,7	6,7
S. adersi	-	5,6,7	6,7
*S. nigritarse**	1	-	-
S. damnosum	5,6,7	5,7	6,7
S. debegene	5	-	-
S. dentulosum	5	-	-
S. rotundum	1	-	-
S. cervicornatum	-	-	6

* Probably mis-identified *S. rutherfoordi*
** abundant numbers?

NOTES

S. debegene and *S. dentulosum* not found again. Could be due to very low flows when samples were taken. A gradual move to further upstream sites by these species would occur.