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Aquatic Invertebrates (Namibian Sector) and Water-Borne Diseases of the Okavango River Basin

Specialist Report prepared by Barbara Curtis for :

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1. BIOLOGICAL ENVIRONMENT

1.1 Fauna - Aquatic Invertebrates

1.1.1 Data available

The most comprehensive published species list for aquatic invertebrates is Curtis (1991) which is somewhat outdated now. This is available as a reprint and possibly on disc. It is purely a species list for the Namibian section of the Okavango River and gives no details on distribution, abundance, habitat or ecology. One could go back to the original sources for details of localities, dates etc. All the references and much of the material upon which this paper is based are housed in the National Museum of Namibia.

Brown *et al* (1992) provides the latest published species list for freshwater snails for both Namibia and Botswana. It is available as a reprint and could possibly be obtained on disc from Dr Brown. It lists all collecting localities as well as numbers of specimens collected, based on Museum records from the State Museum, Windhoek (now the National Museum of Namibia) and the British Museum - Natural History (now the Natural History Museum). Details on when the specimens were collected could be obtained from these Museums as accession numbers have also been included in the paper. Each species is described with general notes on its distribution in Africa. A similar, as yet unpublished, paper has been written on the freshwater bivalves of Botswana and Namibia by Appleton & Curtis. This is also available on paper and possibly on disc. Additional data on freshwater molluscs of both Namibia and Botswana are given in Curtis (1997) as well as a few species not recorded in Brown *et al* (1992). The report by Curtis (1997) is available on paper and on disc.

Various species lists/accounts for individual groups of insects have been published since 1991, e.g. crickets (Günther 1995) and beetles (Perkins & Balfour-Browne 1994 and Uhlig & Jaeger 1995) and work is currently being done on compiling species lists and keys to aquatic insects at the National Museum of Namibia.

Chutter (1997) wrote a report on an assessment of the applicability of the SASS4 biological monitoring method to Namibian rivers, which is available from DWA. In it he gives the taxa found at each of the sampling sites (5 on the Okavango) but these are only down to family level or less.

Unpublished records include material collected by Dr E D Taylor in 1996 and 1997. Some of these specimens are with him in Katima Mulilo, others in the National Museum and some with Dr Ferdy de Moor at the Albany Museum in Grahamstown. There are many specimens in the National Museum of Namibia collected from the Okavango River over the years which have not been identified. Copies of reports by Bethune (1987 & 1992) are available on paper from the Department of Water Affairs: Ecology Section. These describe the collecting localities of some of the National Museum material. The Albany Museum has a small collection from the Okavango in both Botswana and Namibia. Much of the material is unidentified (de Moor, *pers. comm.*) and to get the information it would be necessary to spend a long time paging

through catalogue books.
All the Mollusc material at the National Museum of Namibia is on computer (Dbase), as is the Crustacea material. The insect collection is being computerised, but has a long way to go.

1.1.2 Review of previous and present studies

No detailed, quantitative ecological studies have been done on the Okavango River either in Namibia or Botswana. Bethune conducted various surveys of the Okavango River from 1984 to the present. Invertebrates were collected and the habitats from which they were collected were described (Bethune 1987, 1992), but no quantitative research was done. All specimens collected were lodged with the National Museum of Namibia and still await identification.

Quantitative collections of freshwater molluscs were made from the River in both Namibia and Botswana in 1996 as part of the Okavango EIA for the abstraction of water for Windhoek.

In February 1997 Chutter and others sampled invertebrates at five localities. The samples collected were only identified to family level, but at least they give an idea of the composition of the invertebrate fauna at the various sites, along with a site description. This was a preliminary investigation for a proposed study by Taylor of DWA to undertake a baseline survey of the freshwater macro-invertebrates of the Okavango River. A subsequent monitoring programme will be carried out by DWA using a version of the SASS4 method modified for Namibian conditions based on the results of the baseline survey. A copy of the project proposal is available from DWA. Unfortunately the baseline survey proposed is based on SASS4 sampling methods which, in my opinion, are not adequate for a baseline survey of a river for which very little is known of the invertebrate fauna. They are far too quick to capture all the species present. Only two sites will be sampled - one on the rocky substrate at Popa Falls and one at a site 30 km east of Rundu. Collecting will be carried out bi-monthly (every two months) for one year (12 months).

1.1.3 Overview of the current situation

1.1.3.1 Diversity of invertebrate species present

Nothing can be said about the diversity of micro-invertebrates such as plankton and benthic invertebrates since no surveys or collections have been made of these tiny organisms. As far as macro-invertebrates are concerned, at least 246 species have been identified from the Namibian section of the river (Curtis *et al* 1998). This probably represents less than half of the species present, with some groups having been better covered than others. The known species richness of the Okavango is less than that of the

Caprivi wetlands, but greater than any other Namibian wetland.

The molluscs are the best collected group with a total of 20 gastropod and 10 bivalve species for Namibia and Botswana (Table 1). Seven species occur in Namibia which have not been found in the Delta, while only four species have been found in the Delta thus far. This is a rather low diversity compared with other large African rivers.

Table 1 : Freshwater molluscs of the Okavango River in Namibia and Botswana (Curtis & Appleton 1987; Brown *et al* 1992; Curtis 1997; Appleton, pers. comm). Snails are ranked according to decreasing number of collecting sites where each was found.

SPECIES	RIVER	DELTA
Snails		
Lymnaea natalensis	x	x
Bulinus globosus	x	x
Pila occidentalis	x	x
Cleopatra elata	x	x
Biomphalaria pfeifferi	x	x
Lanistes ovum	x	x
Melanoides victoriae	x	0
Bulinus depressus	x	x
Bulinus scalaris	x	x
Bellamya capillata	x	x
Bellamya monardi	x	0
Afrogyrus coretus	x	x
Bulinus tropicus	x	x
Gabbiella kisalensis	x	x
Gyraulus costulatus	x	x
Cleopatra nsendweensis	x	0
Segmentorbis angustus	0	x
Segmentorbis kanisaensis	x	0
Ferrissia victoriensis	x	x
Ceratophallus natalensis	0	x
Ceratophallus sp.	x	0
Mussels		
Coelatura kunenensis	x	x
Corbicula fluminalis	x	x
Mutela dubia	x	x

Aspatharia pfeifferiana	x	0
Spathopsis wahlbergi	x	0
Mutela zambesiensis	0	x
Unio caffer	0	x
Sphaerium capense	x	x
Sphaerium incomitatum	x	x
Eupera ferruginea	x	x

The second greatest diversity of insects in any Namibian system has been recorded for the Okavango River (Curtis *et al* 1998). This is dominated by the Coleoptera (beetles), Diptera (flies) and Odonata (dragonflies) but probably is a greater reflection of the interest of specialists working in the area than the actual species diversity. Table 2 gives a summary of the numbers of identified insect species found in the Okavango River.

Table 2 : Number of identified insects from the Okavango River (Curtis 1991; Günther 1995; Perkins & Balfour-Browne 1994; Uhlig & Jaeger 1995; National Museum of Namibia records)

ORDER	FAMILY	NO. OF SPECIES
Odonata	all	37
Plecoptera	Perlidae	2
Ephemeroptera	all	10
Trichoptera	all	10
Diptera	all	44
Neuroptera	Sisyridae	1
Hemiptera	all	20
Orthoptera*	Tridactylidae	2
Coleoptera	Dytiscidae	32
	Hydrophilidae	37
	Heteroceridae	1
	Hydrochidae	1
	Sperchidae	3
	Gyrinidae	3
	Total	77
Total insects		203

* Not totally aquatic, but restricted to moist habitats associated with the river.

The recorded diversity of Crustacea (6) and lower invertebrates (10) is extremely low (Curtis *et al* 1997) but this is an artefact of collecting bias rather than a reflection of the true situation. All collecting efforts in the past have concentrated on the river and associated floodplain habitats, and no attention has been paid to the ephemeral rainwater fauna. If the plankton were to be sampled, the diversity of Crustacea would increase markedly.

1.1.3.2 Habitats

From an invertebrate point of view, the Okavango River in Namibia can be divided into the following habitats:

Permanent habitats in the main channel or side channels

Sandy substrates where water is flowing swiftly. This occurs throughout most of the river. The snail *Melanoides victoriae* is the dominant species here, with *Bellamya monardi* and most of the mussel species. A few other benthic invertebrates occur here, but the diversity is not as great as on the rocky substrates or among the vegetation. This habitat is not significantly affected by floods, except for possible deposits of sediments.

Rocky substrates where water is flowing swiftly. The best examples of these are in the Andara area and at Popa Falls. The rock in these areas comprises conglomerate, phyllite and quartzite (Ellery 1997). Here species diversity increases, with species which attach themselves to the rocks, such as caddisfly larvae (Trichoptera), blackfly larvae (Simuliidae), sponges (Porifera) and their associated sponge fly parasites (Sisyridae). Numerous other species find shelter under rocks or in crevices between the rocks, such as various mayfly larvae (Ephemeroptera), dragonfly and damselfly larvae (Odonata), stonefly larvae (Perlidae), riffle beetles (Elmidae), crabs (Decapoda), Sphaerid mussels and earthworms (Oligochaeta). Again, the only effect that flooding would have, would be the possible deposition of silt over the animals. Lowering of the low water level could expose more of the rocky substrate than normal, reducing the available habitat.

The water column. No macro-invertebrates are generally associated with this habitat, which is inhabited by planktonic micro-invertebrates, thus nothing can be said about the species composition at this point.

Vegetated margins of the river. The vegetation provides a habitat for a greater variety of animals. Where the current is swift the diversity is generally low, with species being found which can actively swim against the current, e.g. the shrimps *Caridina* spp. Where the current is slower, species such as crabs, dragonfly larvae, leeches (Hirudinea), water beetles (Dytiscidae, Hydrophilidae and Gyrinidae), various water bugs (Gerridae, Veliidae, Nepidae etc.) and the snails *Bulinus globosus* and *Cleopatra* spp can be found. Flooding may cause a change in species composition and distribution as marginal vegetation becomes temporarily submerged and the "margin" of the river moves outwards.

Permanent habitats outside the main channel

Backwaters and remnant pools. The substrate of these habitats varies from sand to mud and silt with varying amounts of organic sediments. Mostly they are vegetated, but the larger ones may have open water in the centre (Bethune 1991, Curtis 1997). This is the ideal habitat for snail species which are intermediate hosts to parasites of medical and veterinary importance, namely *Bulinus globosus*, *Biomphalaria pfeifferi* and *Lymnaea natalensis*. Other snail species also occur here as well as numerous insects, particularly fly larvae (Chironomidae, Tabanidae, Syrphidae, Culicidae), water scavenger beetles (Dytiscidae) and bugs (Corixidae and Notonectidae). These habitats are subjected to marked seasonal changes. In the dry season they would be subjected to increased salinity due to evaporation, eutrophication (nutrient over-enrichment) due to use by livestock, and a lowering of oxygen levels due to decomposition of plant matter. They are often heavily trampled by livestock and polluted by people. These are the most dangerous contact points between humans and bilharzia. During floods, these habitats would be flushed out and cleaned by floodwater.

Permanent marshes. These occur at the Okavango-Cuito confluence and at places in the Mahango Reserve. The fauna here would have a similar diversity to the permanent backwater pools, but the species composition would differ somewhat. Groups tolerant of poor water conditions, such as the Syrphidae, Chironomidae and certain Dytiscidae would be replaced by a greater diversity of less tolerant species such as mayflies and dragonflies. These are the habitats most likely to be threatened by a drop in water level.

Ephemeral, seasonally flooded habitats

Pools and depressions which fill with rainwater before the flood arrives. These have a fauna more typical of ephemeral rainwater pools anywhere in the country and not necessarily associated with the Okavango River. Species capable of completing their life cycle rapidly are found here, such as seed shrimps (Ostracoda), tadpole shrimps (Notostraca), fairy shrimps (Anostraca) and clam shrimps (Conchostraca). Others are capable of aestivation (surviving the dry season buried in the dry mud) such as *Bulinus depressus* and *B. tropicus*.

Floodplain pools which fill with floodwater. These tend to have a mixed fauna, with elements of the rainwater pools discussed above, elements of the permanent backwater pools and elements of the marginal vegetation associated with the main channel. Some of these fauna live permanently in these habitats while others move in with the floods. This is therefore the most diverse habitat.

1.1.3.3 Distribution and conservation status of species

Most of the molluscs recorded from the Okavango have a much wider distribution in Africa. The most restricted is *Bellamya monardi*, which is known only from the Okavango in Namibia and the lower Kunene River (Brown *et al* 1992). No formal conservation status, such as threatened or endangered, has been given to any invertebrates, but *B. monardi* may be considered to be of conservation importance because of its limited distribution. Other species are known only from a few river systems, such as *Pila occidentalis*, which is endemic to the northern rivers of Namibia as well as the pans in the north and north-east (Brown 1994). The uncommon mussel, *Aspatharia pfeifferiana*, is known only from the Kunene, Okavango and upper Zambezi Rivers, while the common mussel, Coelatura kunenensis, occurs in the former two rivers as well as the Etosha/Cuvelai system (Appleton 1996). Many of the recorded species reach their southern distribution in the Okavango Delta. So far no alien species have been found in the system, but it is probably only a matter of time before they are introduced.

Nothing can realistically be said about the endemism or conservation status of any of the insect species. About 40 have only been recorded from the Okavango, either in Namibia or at all, but not enough is known about the insect faunas further north to discuss endemicity. Many are likely to be endemic to the Okavango River system and particularly those associated with rocky habitats, are of conservation concern due to their restricted distribution. The majority of species, especially those with winged adults, are widespread.

The freshwater sponge, *Potamolepsis* sp., has so far only been recorded from one site in the Okavango and is restricted to rocky areas. It and its associated Neuropteran parasite, the sponge fly, *Sisyra* sp. can be considered vulnerable due to their very restricted habitat. Not enough is known about any of the other groups to be able to comment.

1.2 Environmental Water Demands

Environmental water demand or instream flow requirements have never been assessed for the Okavango River in Namibia. This is not something which can be speculated upon and requires a collaborative effort by all scientists from every discipline who have worked on the system. The South African aquatic scientists have recently reviewed the international literature on the subject (Tharme 1996) and produced a working document outlining the procedure to follow when determining the instream flow requirements for regulated rivers in South Africa (King & Louw 1998).

1.3 Gaps In The Data And Suggestions For Further Research

The invertebrate fauna of any water-body is very important as it forms the basis of the food chain. An understanding of which species are present helps to give an overall understanding of the system. It is also important to know which species are environmentally sensitive. One cannot accurately predict what will happen to the fauna if one does not know which species exist at present, nor can one do any monitoring of changes. A knowledge of species which were present in the past but are no longer present is also invaluable. For that, museum records are important.

There is a need for detailed quantitative and systematic sampling of the aquatic invertebrate fauna of the river at different flow levels, accompanied by identification of the fauna by specialists. There is no point in randomly collecting hundreds of specimens which can at best be identified to family level, as has been done in the past. Ideally, sampling should be done over a long period to establish trends. Taylor (1997) proposes to do a baseline survey, but his method consists of agitating the substrate or vegetation in various habitats for a period of two minutes. This is sufficient for a quick assessment of the most abundant species present, but does not describe the total fauna. For that, detailed and painstaking collection is needed using a variety of different methods.

Of secondary importance is the historical records of what has been collected in the past. It is best to start off by checking positively identified specimens in museums and published literature by experts. If time and funds permit, the unidentified material in the National Museum should be sent to experts for identification, where there are experts who are willing to assist. This should only be done for records where there is adequate information on collecting site and habitat.

It is also recommended that a detailed study of instream flow requirements for the river be undertaken once the baseline data have been collected. Experts in this field, such as Southern Water in Cape Town, should be hired to lead the process since they have had a great deal of experience in South Africa.

1.4 Water-Borne Diseases In Botswana And Namibia

1.4.1 Data available and review of previous and present studies

There is little published literature on water-borne diseases and few unpublished reports. The only comprehensive and reliable survey of bilharzia in the Okavango Region of Namibia was that of Geldenhuys *et al* (1967), thirty years ago. Another was carried out in 1983 by La Grange & Steyn but this used biased sampling methods and crude diagnostic techniques (Schutte 1997). Statistics from three clinics in the Okavango Region of Namibia for 1996 were obtained from the Ministry of Health and Social Services (MOHSS) and are presented in Curtis (1997) (page F-14 of vol. 4 part 3; copy of this "Table 1" included at end of report). A preliminary report by Dr CJH Schutte to the MOHSS on a survey undertaken in October 1997 shows an exceptionally high incidence of urinary bilharzia at three schools in the Okavango Region. The final report will be available once the survey is completed after May 1998. There are no data available on livestock diseases in Namibia (Tolmay, *pers. comm.*).

Dando (1976) reported that malaria was a particular problem in the Delta but that bilharzia had only become a problem since 1973. Annual reports for 1986 and 1987, which are available from the Ministry of Health in Botswana, showed that both malaria and bilharzia were a problem. The 1995 annual report mentioned the problem of malaria but did not mention bilharzia.

The MOHSS in Namibia is currently involved in a comprehensive survey of bilharzia in school children from the Okavango, Omusati and Caprivi Regions (Schutte 1997).

1.4.2 Overview of the current situation

None of the diseases caused by bacteria and other micro-organisms appears to be a problem in the Okavango River either in Namibia or Botswana (Curtis 1997). Malaria is a widespread and very serious problem in both countries, but is not restricted to the river. Rainwater pools and any man-made structures which hold water are sufficient to ensure the continuation of the problem without the river.

The most serious problem associated with the river is bilharzia or schistosomiasis. Both species of human bilharzia known from southern Africa are alive and well in the Okavango River in Namibia, along with their snail intermediate hosts. The MOHSS recognises this as a problem and is now initiating a control programme. Of concern with this control programme is the use of molluscicides to kill the intermediate hosts. The poisons are not species specific and could have a detrimental effect on the other aquatic fauna.

Botswana has undertaken an extensive snail eradication campaign in the past with the result that the disease is virtually unknown in Ngamiland at present. Very few intermediate host snails were found during the 1996 survey (Curtis 1997).

A potential cause of concern is the presence of a large and healthy population of blackflies, *Simulium damnosum* (Simuliidae), which was found in February 1997 at the Andara weir. These tiny flies are vectors for a small parasitic Nematode worm which causes onchocerciasis or river blindness (Chutter 1997). These parasites are a severe problem in west Africa. In the past, neither the parasite nor the vector was present in Namibia or Botswana. With the spread of the vector it is not impossible for the parasite to be spread to the Okavango as well. This could pose a serious new threat to the health of the population living along the Okavango River. Simuliid larvae and pupae attach themselves to rocks in swiftly flowing water and this species is typical of impoundment outlets. Because of the lack of rocky outcrops in the Okavango in Botswana, blackfly are unlikely to spread into Botswana.

1.4.3 Gaps in the data and suggestions for further research

Little is known about the seasonality of bilharzia in Namibia and no data are available on where the main contact points are. Regular monitoring of the situation is required. Appendix 1 gives Schutte's results for three schools in Kavango surveyed in 1997 as well as his proposed plans for early 1998. Once his initial work has been done, regular monitoring of the situation is required. This should be done by testing of school children as well as snail counts at the contact points. The effect of molluscicides on non-target organisms should be monitored very closely.

In Botswana, natural water points used by people should be monitored annually to ensure that bilharzia snails have not re-entered the area.

The weir at Andara should be dismantled to reduce the high population of blackflies breeding there. Very careful monitoring of the human population needs to be done to detect the presence of river blindness.

1.4.4 The situation in Angola

Little is known of the situation in Angola. The World Health Organisation (1987) map of the distribution of bilharzia in Africa shows that both urinary and intestinal bilharzia occur in the Cubango and Cuito catchment areas, but there are no statistics as to how serious the situation is. Looking at the climate and geomorphology of the river, it would appear that conditions would be ideal for the existence of bilharzia. With a mean annual temperature of 18 - 20 °C in the highlands and 20 - 22 °C in the lowlands, both parasites and snails would thrive. The gentle gradient of the river and numerous meanders are ideal for the presence of floodplains and quiet backwaters in which snails breed. Figure 3.6a in the IUCN report on Angola (1992) (copy of this figure included at end of report) shows floodplains along the Cubango and Cuito Rivers only where they border with Namibia and a bit further north. The area near Huambo where the Cubango River starts is shown as swamp, which could be ideal for bilharzia snails.

One factor which may lessen the likelihood of bilharzia, is the low human population density. Around Cuito-Cuanavale the river appears to meander a lot and there are many settlements, so this could be an area of concern. There is a high population density around Huambo where the Cubango starts and where the swamps mentioned above occur. This is a potential site of high infection. For most of their course, both the Cubango and Cuito appear to flow through an area of low population density, however, this is probably misleading since the population is probably concentrated along the river. If the incidence of bilharzia is high in Namibia, it is likely to be as high in Angola.

Malaria is probably rife in Angola, but like Botswana and Namibia it is unlikely to be dependent on rivers. Being a more tropical and much wetter country there could be other water-borne diseases which are unknown in Botswana and Namibia.

It is recommended that a survey be carried out in Angola similar to the one proposed for Namibia by Schutte. The river should be examined for suitable snail sites and children in the vicinity should be tested. The swamp area near Huambo should also be investigated. Rocky areas and any man-made structures in the river such as weirs should be examined for the presence of blackflies which host river blindness.

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