VOLUME 2

HERPETOFAUNA

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EXECUTIVE SUMMARY

The herpetofauna of the IFR Sites and surrounding study area is discussed in relation to those species commonly associated with rivers and streams. Despite a search of abstract journals, no information was found relating to the flow-related requirements for the herpetofauna and amphibians in particular. Within the IFR study area, key species have been identified based on their habitat requirements associated with the IFR Sites. Each species is briefly described and aspects of their lifecycles with reference to flow requirements incorporated. The study was hampered by a lack of knowledge of the habitats present at each IFR Site, such knowledge being limited to a video recording made at six of the sites, together with information gathered during the fish survey at each of the sites. The lack of knowledge concerning critical habitats and flow requirements for the key species and southern African herpetofauna in general is an obstacle to their use in setting IFRs and monitoring the effects of the resultant flow regimes.

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PART 1: INTRODUCTION

1 INTRODUCTION

A literature study of the herpetofauna of the Lesotho IFR study area was undertaken, as part of a study to assess the Instream Flow Requirements for the studied rivers for Project No. LHDA 648. Literature pertaining to southern African reptiles and amphibians mostly concerns taxonomic and ecological aspects. It is comparatively recently that environmental impact assessments have become commonplace in South Africa but even then scant attention has been paid to the herpetofauna with the exception of the rare and threatened species mostly listed in Red Data Books (MacLachlan 1978, Branch 1988). It is still more recent that reptiles and amphibians have been considered in terms of instream flow requirements. South Africa is a semi-arid country with more than two thirds of the country experiencing < 600 mm rainfall per annum and a very high evaporation rate due to the amount of insolation. There are therefore few reptiles which could be considered to be aquatic or wetland species (Jacobsen 1995), none of which would be affected by variability in stream flow, as they are generally found in pools or along the banks of the water bodies. Similarly few amphibians are aquatic, most being seasonal in that they utilise water for reproductive purposes, remaining in moist secluded environments during the arid months, when food availability is low. They have adopted various strategies to overcome the seasonality of the climate and the concomittant lack of food. Aquatic amphibians which are able to breed throughout the year mostly lay small clutches of eggs whereas those that rely on seasonal and ephemeral water bodies may lay large numbers of eggs with the chance of some surviving being correspondingly high. Most aquatic amphibians require standing or slow moving water to breed in, strategies being aimed at the maximum survival of the eggs and young (Channing 1979). It is therefore the availability and sustainability of such habitats that are important to the herpetofauna and the amphibians in particular. The flow-related requirements for the amphibia are concerned with sustaining breeding habitats for sufficient time to permit the eggs to hatch, and the larvae to metamorphose, to a size where they are no longer totally dependent on water.

2 OVERVIEW OF STUDY

2.1 Terms of Reference

The Terms of Reference to assess the herpetofauna of the IFR Sites are as follows:

- From the literature compile a list of species occurring along the sections of rivers below the LHWP dams on the Matsoku, Malibamatso, Senqunyane and Senqu Rivers.
- View video recordings of these river sections in order to determine the scope, extent and condition of the habitats presented within the valley bottoms.
- Review and compare the herpetofaunal inventory with the information obtained from the videos, in order to refine the list where necessary and compile a community profile for the habitats.
- Compile a short life history sketch for key taxa from the literature and available data bases as laid out in the draft terms of reference where such information is available.
- Assess whether there are any historical changes in the distribution of these species, and elucidate the reasons for such changes. This will again be limited to the available historical record available in the literature, as no detailed density or distribution studies have been carried out on a systematic basis.
- Assess the flow-related requirements for these taxa with respect to life history strategies and habitat maintenance.
- Consult the available literature on flow-related requirements for these taxa and of any other comparable species, even alien taxa but with similar life-history strategies. It may be necessary to access Internet facilities in this regard, as well as Abstract Journals for applicable references.
- Compile a report on the findings and where necessary propose mitigatory measures.
- Attend IFR Workshop and provide herpetofaunal input into a monitoring programme for the rivers, including habitat-related information for incorporation into assessments at the workshop.

2.2 Dates of the study

The study was conducted during January and February 1999.

2.3 Limitations of the study

The limitations of the study are that several assumptions have to be made including the presence or absence of species from the IFR Sites. No detailed work on the herpetofauna was carried out at the IFR Sites, with the exception of incidental observations by J. Rall of ECOSUN, providing only cursory information about the herpetofauna. A detailed inspection of each site may have yielded some information regarding abundance and utilization of the site by the herpetofauna but this did not form part of the TOR.

PART 2: LITERATURE REVIEW

3 INTERNATIONAL REVIEW OF THE DATA USED AS INPUT TO INSTREAM FLOW ASSESSMENTS

Despite a search of the Zoological Record (1975-1998, Ecological Abstracts 1990-1995 and Ecology Abstracts 1992-1993) no literature was found concerning instream flow requirements for amphibians. Discussions with fish and water quality workers (Dr N. Kleynhans, DWAF and J. Rall, ECOSUN, pers. comm.) have also not led to additional information. With this in mind, comments concerning the role of amphibians in river ecosystem functioning and their flow-related requirements have been made, as follows:

3.1 Role of Herpetofauna in river ecosystem structure and functioning

The herpetofauna play a role in river ecosystem structure and functioning, forming part of the food chain linking aquatic and terrestrial systems, but they do not contribute significantly to soil movement, water movement or other forms of habitat modification which may lead to changes in river structure and functioning.

3.2 Roles of the Herpetofauna in instream flow assessments

The roles of the herpetofauna in instream flow assessments are those essentially pertaining to habitat requirements for adult, egg and larval stages. Each species has specific habitat requirements, some very broad, others narrower. While Lesotho reptiles are not directly affected by instream flows, some species are dependent on amphibians as a source of food, and these may be affected by changes in instream flows. Unfortunately very little research has been conducted on the specific flow-related habitat requirements for species, with the result that most assessments are based on anecdotal observations and are therefore largely subjective.

3.3 Kinds of herpetofaunal data used in instream flow assessments

Most of the herpetofaunal data used in instream flow assessments pertains to the maintenance of habitat quality, particularly for the amphibians, their egg and larval stages. The herpetofaunal data needed includes an assessment of habitats required by the various life stages, for the continued survival of the species.

4 THE HISTORIC NATURAL CONDITIONS OF LESOTHO RIVERS WITH RESPECT TO THE HERPETOFAUNA

There is no literature available that accounts for any changes in herpetofaunal distribution or abundance in Lesotho. It is likely that anthropogenic disturbances have changed the availability of specific habitats along the rivers, which may be detrimental to some herpetofaunal species but advantageous to others. It is also likely that some reduction in abundance has also occurred due to habitat degradation arising from agriculture, overgrazing, the frequent use of fire to promote grazing and the frequency of contact with man, which increases proportionately with the growth of the human population. Mouton & Van Wyk (1993) expressed their concern at the low number of snakes found during a survey of the reptiles of the Katse Dam catchment, which they attribute to decimation by people, who kill any snake on contact. This attitude has been confirmed subsequently, not only for snakes but for other fauna as well, particularly around villages (Jacobsen 1997, Jacobsen & Leoege 1998). It is therefore considered that some decline has taken place but no quantitative data exist. Similarly the conditions of the rivers and other water bodies have probably deteriorated as a consequence of overgrazing and trampling, leading to incised livestock paths, which promote rapid runoff of water, creating dongas. The resultant runoff contaminated with dissolved and insoluble solids has changed the condition of the rivers, seeps and ponds, the waters frequently being stained red as a result. As a consequence, extensive alluvial fans are found along most tributaries at their confluences with the main rivers (Video recording, Southern Waters). The trampling

of seeps and marshes causes a deterioration in the quality of habitat available to the amphibians in particular.

5 A REVIEW OF THE PHYSICAL HABITATS AND FLOW REQUIREMENTS FOR THE HERPETOFAUNA

Appendix 1 lists the species of reptiles and amphibians likely to be found below the proposed dam sites. According to the literature (Branch 1988a, 1998, Bates 1992) a total of 20 amphibian and 32 reptile species may occur in the study area, although some species may only marginally occur there. The mountainous terrain provides for considerable habitat heterogeneity, which is however largely repetitive due to the geomorphological forces working on the plateau. An attempt has been made to identify the habitats available to the herpetofauna and that are listed in Appendix 2,3 and 4. As all of the IFR Sites lie at altitudes at or below 2100 m, high-altitude species and habitats are excluded, and no attempt has been made to incorporate them in the following discussions.

As southern Africa is mostly semi-arid, with two thirds of the country receiving less than 600 mm of rain per annum and with a high evaporation rate, there are few aquatic or wetland associated reptile species (Jacobsen 1995). This applies also to Lesotho, for although it has a higher rainfall, it has a more rigorous climate, with low ambient temperatures and sudden changes even in summer. This is reflected in the low number of species found in the country. Among the reptiles, only the Brown water snake *Lycodonomorphus rufulus,* which occurs peripherally in Lesotho, can be considered aquatic and commonly found along rivers and ponds, in search of frogs, which constitute its prey. Several other species such as the Rinkhals *Hemachatus haemachatus*, Aurora house snake *Lamprophis aurora*, Herald snake *Crotaphopeltis hotamboeia* and the Rhombic skaapsteker, *Psammophylax rhombeatus* have been included as wetland species (Jacobsen op. cit), as they commonly occur in vleis and other moist habitats. None of the other species listed in Appendix 3 are wetland associated.

Amphibians are less affected by the cold, but with some exceptions, are more dependent on a moist environment. Although some reptile and amphibian species are widespread with wide habitat tolerances, many have more specific habitat requirements. These are listed in Tables 5.3 and 5.4. Amphibians are well represented in Lesotho, and include some endemic and near endemic high altitude species, such as the Aquatic river frog, *Rana vertebralis*, the Drakensberg river frog, *R. dracomontana* and the Berg stream frog, *Strongylopus hymenopus*. The latter appears

to be restricted to the catchments of the rivers above an altitude of 2300 m, and is therefore outside of the area specified in the TOR. Similarly the Natal ghost frog, *Heleophryne natalensis*, although being widespread in the catchment, is restricted to fast flowing tributaries of the major rivers (J. Rall, pers. comm.) and therefore beyond the limits of the study area.

While all reptiles lay their eggs in sheltered positions on land, where the young emerge during summer, grow rapidly and go into hibernation in winter, the amphibians, with the exception of a few species, are dependent on water for reproductive success.

Reproduction in most species is therefore restricted to the summer months, when environmental conditions are optimal, for reproduction and the survival of the young. According to Balinsky (1969) weather changes may instigate spawning activity on any particular day. Such changes include that of temperature and rainfall, cues in the case of the former being a rise or fall and extent, and in the case of the latter, the duration and amount of rain falling.

Oviposition sites of amphibians also exhibit a wide range of conditions. Van Dijk (1971) subdivides the sites as shown in Table 5.1 (adjusted for Lesotho amphibians.)

As the majority of species are dependent on ponds, mostly seasonal and rain filled, or slow moving water, they lay large numbers of eggs, which hatch rapidly, the tadpoles also spending the shortest possible time in a larval state, to avoid the possibility of the pool drying up. Immature frogs emerge from the water in time to enter hibernation at the onset of winter. It is only the burrowing and riverine frogs that differ from this lifecycle. In the case of the latter, water is usually present and of varying depths, which permits these frogs to over-winter in both larval and adult stages, without having to emerge from the water, which at this time may be warmer than surrounding terrestrial conditons. Under these conditions, the tadpoles do not need to develop rapidly, and take from nine months to two years to metamorphose in the case of *Heleophryne natalensis* and *Rana angolensis* (Wager 1986, Lambiris 1988a), and longer in the case of *R.. fuscigula* (Wager 1986).

Van Dijk (1972) divides southern African anuran tadpoles into five basic groups according to their morphology, behaviour and habitat, all of which are exhibited by Lesotho amphibians in Table 5.1.

Many species display a behaviour between two of these groupings, such as the tadpoles of the Natal ghost frog *Heleophryne natalensis* which are rheophilic living in fast flowing water, but is a bottom dweller, feeding and hiding under stones and boulders in the stream. The food of most tadpoles is aquatic macrophytes and algae. Some tadpoles include invertebrate prey in their diet and some will also scavenge on dead animals. Only a few species, such as *Xenopus* and possibly *Phrynobatrachus* tadpoles, are filter feeders or partly so. No literature pertaining to flow-related requirements for the South African herpetofauna is available. Reptiles and amphibians have only recently been part of IFR Workshops including that of the Mvoti, Sabie, Nkomazi and Umhlatuzi Rivers.

Table 5.1 Amphibian Habitat Sites

Habitat	**Genus**
Oviposition Sites	
Moss and humus:	*Arthroleptella;*
Rocky streams and stream beds	*Heleophryne*
Turbulent water	*Heleophryne;*
Aquatic plants	*Xenopus*, *Phrynobatrachus, Ptychadena, Bufo, Cacosternum, Kassina;*
River bottom	*Rana, Tomopterna, Bufo;*
Grassy verges	*Strongylopus;*
Soil	*Breviceps;*
Behaviour and Habitat of Anuran Tadpoles	

Subterranean	*Breviceps;*
Pelagic	*Xenopus;*
Inbetween	*Cacosternum, Kassina;*
Hydrophytophilic	*Strongylopus, Phrynobatrachus, Ptychadena;*
In between	*Strongylopus;*
Benthic or Bottom dwelling	*Rana, Tomopterna, Heleophryne, Strongylopus;*
In between	*Heleophryne, Strongylopus*;
Rheophilic	None.

PART 3: STUDY AREA

6 GENERAL DESCRIPTION OF THE HERPETOFAUNA IN THE STUDY AREA

Appendix 1 lists a total of 20 amphibian, 14 lizard and 18 snake species which may occur within the catchments of the Matsoku, Malibamatso, Senqu and Senqunyane Rivers, at the elevations of the IFR Sites. This information is based on distributions recorded in the literature, extrapolated to include the study area, for which little information is available. Mouton & Van Wyk (1993) and Van Dijk (1996) only recorded seven lizard, five snake and seven amphibian species, respectively, during their survey of the Katse Dam catchment. This was also substantiated by cursory observations during subsequent visits by myself although some species not seen by these authors have also subsequently been seen. The IFR Sites include a wider range of habitats from 2100 m descending to 1500 m along the Senqu River, which permits the inclusion of some species that do not occur at high altitudes. Considering the climate, this represents a considerable species richness. This is no doubt due to the range of habitats available to the taxa, as well as an altitudinal and climatic range. Many of the species recorded have wider distributions in South Africa and are eurytopic. The fact that there are more amphibian species present than either snake or lizard species is a reflection of the amount of rainfall, and the number and extent of aquatic habitats available.

The lizards fall into two basic categories, namely terrestrial or rupicolous, with six species terrestrial and eight rupicolus, i.e., usually associated with a rocky habitat, including bedrock, rocky outcrops and cliffs. The snakes on the other hand are mostly terrestrial with two species fossorial, one aquatic and 15 terrestrial. The amphibians reflect again a different pattern, with five being aquatic or near aquatic, two fossorial and 14 terrestrial, most of the latter only utilizing water bodies seasonally.

Most reptiles and amphibians are only seasonally active, spending the harsher winter months in seclusion, usually in burrows, under rocks or in crevices, emerging only under more suitable climatic conditions. Some lizards and snakes may be found above ground or sunning themselves during winter, and it is only the aquatic amphibians that may be active throughout the year. Such species include the Common, Dark-throated and Aquatic river frogs, which even in winter may be heard calling, the latter active even under a covering of ice.

6.1 Purpose of IFR Sites

The purpose of the IFR Sites is to identify various habitats and flow-related conditions along the rivers in the study area, where some monitoring and modelling of the water requirements for the physical and biotic environment can take place. It is impractical to attempt to assess the full length of these rivers.

6.2 Location of IFR Sites

The IFR Sites located along the Senqu River and its major tributaries, at or below an altitude of 2100 m.

6.3 Extrapolation of data from IFR Sites to the rest of the study area

The data from the IFR Sites appear to be representative of the rivers in the study area. Conclusions based on these can be extrapolated to the rest of the study site.

PART 4: STUDY PROGRAMME

7 OVERALL PLAN

7.1 Objectives

The objectives of the study were to compile an inventory of the herpetofaunal community found along the study rivers and environs and assess their flow-related habitat requirements.

7.2 Timetable

Report to be completed by 18 February 1999.

7.3 Overview of activities

Activities include:

- literature review of the role of reptiles and amphibians in an assessment of instream flow requirements for rivers, nationally and internationally;
- viewing of a videotape of the rivers in the study area;
- consultation with J. Rall, regarding the study rivers, IFR Sites and amphibian species recorded;
- compilation of report.

As this study is essentially a desktop study, IFR Site specific lists of the herpetofauna likely to occur were not compiled. Instead the focus for the distributions was study area as a whole (see Appendix 1). For the amphibia, however, the habitat types reported to be available at each IFR Site were used to assess which species would be likely to be found there. Some verification of these distributions was supplied by J. Rall, from data collected during visits to the respective sites.

PART 5: DATA PRESENTATION

8 IFR SITE 1 (2100 m a.s.l.)

8.1 General overview of the characteristics of the IFR Site 1

The characteristics of the IFR 1 site include a deep pool extending across the river, with vegetation along the banks. The water is turbid. Bedrock extends across the river forming an island. Rocks protrude from the water. The water anastomoses around islands at low flow situations. A vegetated island is found downstream.

8.2 Description of the herpetofauna at IFR Site 1

According to the habitat available at IFR Site 1, it is likely that two species are present, namely: the Common river frog *Rana angolensis* and the Cape river frog *R. fuscigula*. It is also possible that the Common platanna *Xenopus laevis* may also occur. Specimens of *Rana dracomontana* have been collected from the Matsoku River, and according to J. Rall, *R. fuscigula* has also been observed during a previous study.

8.3 Results

No amphibians were recorded at this site during this study (J. Rall, pers. comm.).

8.4 Identification of key species, with reasons

The identification of key species can be considered from two poles, namely:

- species that are common and easily monitored, or;
- from taxa that are rare and difficult to obtain.

Both approaches can be used. In the case if IFR Site 1, the Cape river frog may present a good key species for determining the IFR. However, once the IFR is in place it would be necessary to establish their densities and localities before the effects of varying flow on these animals can be ascertained.

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9 IFR SITE 2 (1860 m a.s.l.)

9.1 General overview of the characteristics of the IFR Site 2

This IFR Site lies downstream of Katse Dam on the Malibamatso River, with rocky banks that are well vegetated. There is a rocky sill extending across the river and water trickles through vegetation providing shallow water. A deep channel lies along the sill, and there is a series of rapids formed by rocky bands on the river. There is a silt layer up to 70 cm deep, possibly the result of soil displacement resulting from construction work during the building of Katse Dam.

9.2 Description of the herpetofauna at IFR Site 2

Rana angolensis, *R. vertebralis* and *Xenopus laevis* have been recorded from the site and the presence of *Bufo rangeri* and *R.. fuscigula* is probable.

9.3 Results

Xenopus laevis is abundant and 64 were sampled in an area of about 50 m^2 (J. Rall pers. comm.). Such densities could be attributed to the deposition of silt, providing more suitable habitat for this amphibian. In addition, the Aquatic river frog *Rana vertebralis* was recorded at the site. IFR Site 2 falls along the altitudinal watershed of this species.

9.4 Identification of key species, with reasons

Rana vertebralis could be considered a key species, as this site may represent marginal habitat for the species. It is likely that the species is already under pressure to survive in what may be sub-optimum environmental conditions and therefore is likely to react to increasing stress imposed by changes in microhabitat conditions. It is possible that the Aquatic river frog may not adapt to such change. Other common species are also available

(9.2) for this purpose. Additional comments are contained in Chapter 8.4.

10 IFR SITE 3 (1830 m a.s.l.)

10.1 General overview of the characteristics of the IFR Site 3

A portion of IFR Site 3 at Paray is a large pool, with rocky sills. The rest of the site consists of rapids, and emergent rocks. During lowflow, pools form on the bedrock, and backwaters are present.

10.2 Description of the herpetofauna at IFR Site 3

Like IFR Site 2 previous sites, IFR Site 3 is suitable for several amphibian species, such as the Common river frog *Rana angolensis* and the Cape river frog *R. fuscigula*, with the Common platanna *Xenopus laevis* possibly also present.

10.3 Results

No adult frogs were recorded during this study, but *Phrynobatrachus natalensis* tadpoles were found here, indicating that breeding takes place in shallow water.

10.4 Identification of key species, with reasons

As for Chapter 9.4.

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11 IFR SITE 4 (1680 m a.s.l.)

11.1 General overview of the characteristics of the IFR Site 4

At IFR Site 4 there is a long pool, with a rock shelf along one bank. The banks are steep on one side and vegetated. Much of the banks are rocky, with some silt. Riffles are present at the downstream end of this pool. Sandbanks and silty sandbanks are found. Willows *Salix babylonica* grow along the banks.

11.2 Description of the herpetofauna at IFR Site 4

The available habitats are suitable for species such as the Common and Cape river frogs and the Common platanna.

11.3 Results

No amphibians have been recorded here to date.

11.4 Identification of key species, with reasons

Comments pertain as to Chapter 9.4.

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12 IFR SITE 5 (1620 m a.s.l.)

12.1 General overview of the characteristics of the IFR Site 5

At IFR Site 5, there are riffles, and a sandbank with an alluvial fan extending into a large pool, with bare banks.

12.2 Description of the herpetofauna at IFR Site 5

With a bare shoreline, it is unlikely that the site is of importance to the herpetofauna, although the Common Platanna *Xenopus laevis* may occur. It was not recorded by J. Rall (pers. comm.) while sampling the site for fish during this study.

12.3 Results

No amphibians were recorded.

12.4 Identification of key species, with reasons

Comments pertain as to Chapter 9.4.

13 IFR SITE 6 (1530 m a.s.l.)

13.1 General overview of the characteristics of the IFR Site 6

IFR Site 6 comprised a large run, with well developed vegetation along the steep sided banks.

13.2 Description of the herpetofauna at IFR Site 6.

The herpetofauna are likely to limited to the most common species *Rana angolensis* and *R. fuscigula* and possibly *Xenopus laevis*.

13.3 Results

No amphibians were recorded during this study.

13.4 Identification of key species, with reasons

The same comments pertain as per Chapter 9.4.

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14 IFR SITE 7 (1950 m a.s.l.)

14.1 General overview of the characteristics of the IFR Site 7

No description of habitats is available for the IFR 7 site. These will be addressed at the IFR Workshop.

14.2 Description of the herpetofauna at IFR Site 7

Similar to other sites, with the exception that both *Rana vertebralis* and *R. dracomontana* have been recorded from this site.

14.3 Results

Rana vertebralis has been recorded from the Marakabei area (J. Rall pers. comm.). This site is likely to be marginal, the species being mainly found in the sandstone gorge upstream of the Lesobeng-Senqunyane confluence.

14.4 Identification of key species, with reasons

The Aquatic river frog could be considered to be a key species occurring at the margin of its distribution. Any changes to its habitat requirements would possibly be reflected in the survival of the taxon at that site.

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15 IFR SITE 8 (1560 m a.s.l.)

15.1 General overview of the characteristics of the IFR Site 8

No habitat details are available for the IFR 8 site. These will be addressed at the IFR Workshop.

15.2 Results

None obtained.

15.3 Identification of key species, with reasons

The same comments pertain as to Chapter 9.4.

16 SUMMARY OF PRESENT-DAY CONDITIONS OF THE LESOTHO RIVERS RELATIVE TO THE NATURAL CONDITION OF THE HERPETOFAUNA

The condition of present-day Lesotho rivers with regard to the herpetofauna is adequate in providing the habitats for such species that depend on these. The herpetofauna in the main river reaches are eurytopic, which means that they have broad habitat tolerances and are able to survive and reproduce in a variety of habitats. It is in the upper reaches of the rivers, mostly outside of the study area, where water quality may be more critical as some species of amphibians such as the Natal ghost frog *Heleophryne natalensis*, Drakensberg stream frog *Strongylopus hymenopus* and to a lesser extent the Aquatic river frog *Rana vertebralis* may be vulnerable to changes in river flow and condition.

PART 6: FLOW-RELATED INFORMATION

17 FLOW RELATED INFORMATION

After viewing the video tape of the rivers forming the Lesotho IFR study, it appears that the Matsoku, Malibamatso, Senqu and Senqunyane Rivers are very similar in terms of their geomorphology, as it relates to habitats for the herpetofauna. However the Senqunyane exhibits the best habitat conditions. Alluvial fans are found where most substantial tributaries meet the main river, such tributaries frequently anastomosing or winding across such deltas. Habitats include off-channel ponds, backwaters, areas of shallow, slow moving water, vegetated margins and rapids, all of which may be affected by a change in the flow regime. A few islands were also seen along the Senqunyane River. Most of the off-channel ponds and backwaters are found along or behind sandbanks, usually with no vegetation cover, and therefore of limited suitability for amphibians which may be exposed to predation. Most amphibians require some cover from which to call. The steep, mostly barren, riverbanks preclude most amphibian species from breeding, with the exception of aquatic or near aquatic species and some mostly terrestrial species with broad habitat requirements, for which backwaters and off-channel ponds are available.

During floods it is likely that semi-terrestrial species, such as the Common river frog *Rana angolensis*, Common puddle frog *Phrynobatrachus natalensis* and possibly the Cape river frog *Rana fuscigula* take shelter under vegetation along the banks. The more aquatic species would take refuge in sheltered sites on the river bed under rocks and along the river bank where they are protected from the accelerated water flow by bottom or lateral friction. Little is known of survival tactics under such conditions.

The following taxa could be affected by changes in the flow regime of the rivers:

- *Xenopus l. laevis*
- *Bufo rangeri*
- *Rana angolensis*
- *R. fuscigula*
- *R. dracomontana*
- *R. vertebralis*
- *Phrynobatrachus natalensis*

None of these are Red Data Book species, five are widely distributed in southern Africa, while two are endemic to the highlands. With the possible exception of the Common puddle frog *Phrynobatrachus natalensis*, they could be considered as key species, at least in the egg and larval stage, as they may reflect changes in habitat condition, in a reduction in abundance of adults. A short biographical sketch of these taxa is included below.

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18 ***XENOPUS L. LAEVIS*** (COMMON PLATANNA OR CLAWED FROG)

18.1 Description

A dorso-ventrally depressed frog with claws on the inner three toes of the hindfeet. Up to 120 mm snout-vent. The head is small, with a rounded snout, and eyes directed upwards, subtended by a very short tentacle. Body robust, smooth and slippery, with stitch-like sensory organs laterally. Forelimbs small, hindlimbs large, well muscled. Toes fully webbed. The dorsal colour is a mottled olive-brown to grey, with irregular darker blotches. Ventrally off-white to grey or yellowish-brown.

18.2 Distribution and abundance

Widespread thoughout southern Africa, including Lesotho. May be extremely common locally and extend up most of Lesotho rivers.

18.3 Conservation status

Not threatened.

18.4 Habitat and microhabitat

Eurytopic inhabiting most permanent standing bodies of water, rivers and even cattle drinking troughs, at altitudes ranging from sea level to 2850 m (Van Dijk 1996, Table 1). They are able to survive in stagnant pools and even in polluted water. Being an aquatic species they rarely emerge from water, except during the rainy season when they travel overland from one drainage system to another. More rarely they may move away from drying ponds to more permanent supplies of water. Rose (1962) records them aestivating underground in dried-up pools only to emerge when substantial rain has fallen. Recently, platannas were found in small pools along a seasonal stream which is separated from a permanent water source by cliffs of the escarpment above the Steelpoort River (Jacobsen 1999), which seems to substantiate such accounts. They occur in quiet water, avoiding swift flowing conditions.

18.5 Feeding ecology

They are predators and scavengers feeding on invertebrates, small tadpoles, fish and the carcasses of dead animals.

18.6 Reproduction

The species breeds in quiet water during the summer months from September to March (Balinsky 1969) but may extend to April, laying several thousand eggs, attached to stones, sticks and submerged vegetation (Wager 1986). Hatching is rapid, taking 48 hrs and the young tadpoles are gregarious, moving about in large aggregates.

18.7 Flow related aspects of the lifecycle

No information is available concerning flow requirements, with the exception that they require standing or slow moving water for the eggs and tadpoles to survive. They are not rheophilic, the tadpoles hanging head down in the water, keeping together in quiet water.

18.8 Anticipated sensitivity to changes in flow regime

It is unlikely that the species will be unduly sensitive to changes in flow regimes associated with damming as habitats will still be available for the adults, eggs and tadpoles. However the release of water from the dam may create untimely surges which may affect reproductive success by washing away ova or tadpoles at critical periods of time.

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19 *BUFO RANGERI* (RAUCOUS TOAD)

19.1 Description

A large toad reaching 100-mm snout - vent length. Body robust, characterised by a dry warty skin; parotid glands prominent; limbs short with glands under the forelimb flattened, forming a more or less continuous white ridge. Feet webbed, and toes usually with a well defined margin of webbing. Olive brown to olive grey with a paravertebral series of irregular dark brown blotches. Snout with triangular light coloured patch. Interorbital bar usually continuous, rarely split into two.

19.2 Distribution

Widespread in South Africa, including Lesotho. No estimates of abundance are available but the species appears to be common around Katse Dam.

19.3 Conservation status

Not threatened

19.4 Habitat and microhabitat

Usually found in grassland and open woodland at altitudes ranging from sea level to 2500 m (Van Dijk 1996, Table 1).

19.5 Food

Feeds on invertebrates.

19.6 Reproduction

Breeds during the summer months only. Van Dijk (1996) records finding young tadpoles in November, suggesting a spring breeding season. The double strings of egg are deposited in rivers, streams and ponds, usually in deeper water, and attached to emergent aquatic plants. The eggs

hatch in four days and metamorphosis takes five to six weeks (Wager 1986).

19.7 Flow related aspects of the lifecycle

Little is known of the life cycle of the species. It usually lays its eggs in slow moving or standing water, and the tadpoles were found near the confluence of the Khohlo Ntso and Malibamatso Rivers (Van Dijk 1996) which indicates that there is quiet water in that section.

19.8 Anticipated sensitivity to changes in flow regime

Should the changes include disruptions of the breeding cycle by introducing fast flowing water at critical times in the incubation of the eggs and the development of tadpoles, it will adversely affect population densities of the species within the study area.

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20 *RANA ANGOLENSIS* (COMMON RIVER FROG)

20.1 Description

Medium sized frogs reaching 80-mm snout - vent length. Snout pointed, body robust, skin smooth, with entire and or interrupted longitudinal ridges; hands with subarticular tubercles at base of digits only; legs long, and powerful; feet well developed and webbed. Webbing extensive, mostly with two phalanges on both sides of 4th toe free of web, one of 5th toe and 1,5 - 2 of 1st toe free. Ground colour variable light to dark brown to various shades of green. More or less rounded mostly blackish to green or reddish-brown blotches, more or less symmetrically arranged or scattered over the back, rarely confluent forming interrupted transverse bars. A pale cream to yellowish-green to brown vertebral stripe is commonly present. Sides of body mottled grey as is the posterior side of the thighs. Underside of throat marbled grey, sometimes extending onto the chest, or according to Lambiris (1988b), brown or black. Ventrally white.

20.2 Distribution and abundance

Widespread in southern Africa extending as far north as Ethiopia and in the west, Angola, but excluding the western and southern Cape (Poynton & Broadley 1985). The species is common and a single 9 m^2 pond may have as many as 30 individuals, but densities vary from area to area according to the condition of the habitat. Interestingly the species was not recorded by Van Dijk (1996), from the catchment of the Katse Dam. One specimen was collected by J. Rall at IFR Site 2 during this study.

20.3 Conservation status

Not threatened.

20.4 Habitat and microhabitat

The species occurs along streams, rivers, dam and ponds wherever permanent water is found, up to altitudes of 2200 m a.s.l. The frogs spend the day aestivating under fringing vegetation often up to 100 m from the water. They leap into the water if disturbed and bury themselves in the mud and debris on the bottom. According to Channing (1979), *R. angolensis* is eurytopic, utilizing 19 microhabitats in Natal. The tadpoles are usually found in poorly vegetated, shallow, standing or slow moving water, burying themselves in the mud on the bottom on being disturbed, frequently raising a cloud of fine particles to obscure their position.

20.5 Feeding ecology

The adults feed on a wide variety of invertebrates, mostly insects, while the tadpoles are detritus feeders, including plant and animal matter lying on the bottom of the pool.

20.6 Reproduction biology

Over most of their range, these frogs reproduce throughout the year, laying thousands of eggs (Wager 1986). Other authors (Channing 1979, Lambiris 1988a,b) dispute this, recording 400-500 eggs being laid at a time. Channing (op. cit) states that the eggs are deposited in shallow, calm water. According to Balinsky (1969) spawning is a complicated process with many environmental variables, which are difficult to quantify particularly in such species as the Common river frog, which exhibits such an extended breeding season. The eggs hatch in about seven days. Most pools exhibit a range of tadpole sizes and ages. The tadpoles take from nine months to two years or even longer to metamorphose (Wager op cit), while Lambiris (1988) records 9-12 months. The frogs are therefore dependent on an adequate water supply.

20.7 Flow related aspects of the lifecycle

Despite its wide distribution and abundance, very little is known of the Common river frog. This applies especially to the flow requirements for the species, except that the eggs and young are found in quiet waters. Because of the slow growth rate of the tadpoles, changes in the flow regime may affect the survival of the eggs and tadpoles as a sudden flood may remove all the eggs and very young larval stages.

20.8 Anticipated sensitivity to changes in flow regime

Considering the wide tolerance in habitat utilization, it is unlikely that these frogs will be seriously affected by a change in the flow regime, provided that they have access to sufficient habitat, throughout the year. Such habitat includes off-channel pools, backwaters and other shallow, slow moving water where reproduction can take place. Untimely flooding may result in the eggs and young tadpoles being washed away. Should reproductive activity be compromised then it will affect the viability of populations of these frogs.

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21 *RANA FUSCIGULA* (CAPE RIVER FROG)

21.1 Description

Medium to large frogs with a snout-vent length of up to 120,0 mm (Lambiris 1988b) or 125,0 mm (Wager 1986). In contrast to the previous species, the snout is more rounded than in *R. angolensis*, the body is robust and the hindlimbs powerful. The webbing on the hindfeet is similar to that in *R. angolensis*, but usually more fully webbed with only one phalanx on the 4th toe free of web, one phalanx of the 1st toe and less than one phalanx of the 5th toe free of web. The species' colouration is very similar to that of *R. angolensis*, but with a heavy dark mottling under the throat extending onto the chest and frequently, on the abdomen. Elsewhere white.

21.2 Distribution and abundance

Endemic to South Africa and Lesotho, ranging from the Highveld of Mpumalanga, Gauteng and the North West Province south, through the Free State to the southern and western Cape Province. Appears to be less abundant than the Common river frog with which it co-exists over much of its range. No quantifiable data are however available in this respect.

21.3 Conservation status

Not threatened.

21.4 Habitat and microhabitat

Similar habitat requirements to that of the previous species, with which it frequently co-exists, including ponds, streams and rivers, in grassland to open woodland, at altitudes of up to 2000 m a.s.l. Recorded aestivating under stones (Lambiris 1988a, Jacobsen 1990) and clods of earth near the waters edge (Jacobsen op cit), as well as lying up under the cover of vegetation close to water. It does however appear to be more aquatic than the preceding species. According to Channing (1979) the species is stenotopic, inhabiting a narrow range of microhabitats, mainly associated with the riverbank and river.

21.5 Feeding ecology

Little is known of the diet of the species, but like the Common river frog it preys on invertebrates such as beetles, grasshoppers, bugs, ants and spiders (Channing 1979), while Rose (1962) refers to cannibalism in captivity, as well as eating fish. Channing (op cit) records that caterpillars, millipedes and crabs were also eaten. Borquin & Channing (1980) state that it is known to feed on crabs along the waters edge.

21.6 Reproduction

Like the previous species the Cape river frog is apparently reproductive throughout the year. According to Lambiris (1988a) the preferred breeding site is deep quiet water with a sandy or silt substrate. According to Wager (1986) about 15 000 eggs are laid singly or in patches, adhering to stones and vegetation in shallow water, or the eggs are simply deposited on the bottom (Channing 1979, Borquin & Channing 1980, Lambiris 1988a). These hatch after 7-10 days according to the temperature of the water and metamorphosis takes from 9 months to three years (Wager 1986). Power (1927) in Balinsky (1969) recorded metamorphosis in 81 days in water averaging 37 ^{o} C (range 25-40 ^{o} C) but said that the larval stage could last three years or more.

21.7 Flow related aspects of the lifecycle

Little information exists regarding flow requirements for the species, and that available is limited to the basic statements outlined previously. The adults prefer quiet water and can escape from more turbulent conditions by

emerging from the water. The eggs and tadpoles on the other hand require slow moving water in which to develop, but the units of current speed that can be coped with have as yet not been established.

21.8 Anticipated sensitivity to changes in flow regime

It is unlikely that the species will be unduly sensitive to changes in flow regime associated with damming as habitats will still be available for the adults, eggs and tadpoles. However the release of water from the dam may create untimely surges which may affect reproductive success by washing away ova or tadpoles at critical periods of time.

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22 *RANA DRACOMONTANA* (DRAKENSBERG RIVER FROG)

22.1 Description

A medium sized species reaching 67-mm snout-vent length. Very similar in appearance to *R. angolensis* and *R. fuscigula*, and according to Lambiris (1988a,b) differing morphologically, only in the degree of webbing on the hindfeet. In *R. dracomontana* there are usually 1,5 phalanges on the outer side and two phalanges on the inner side of the 4th toe free of web and less than one phalanx of the 5th toe free of web. The only other differences appear to the call. In colour, indistinguishable from *R. angolensis*.

22.2 Distribution and abundance

According to Channing (1979) and Lambiris (1988a,b) the species is only known to occur in Lesotho. Owing to the difficulty of recognising the taxon no details of its abundance are available.

22.3 Conservation status

Endemic. Not threatened.

22.4 Habitat and microhabitat

According to Channing (1979) and Lambiris (1988a,b) the species is found along rivers of the Lesotho plateau at an altitude of 3000 m. However Van Dijk (1996) found the species to be common throughout the Katse catchment, down to 1890 m a.s. l. Specimens collected by J. Rall from several IFR Sites appear to be *R. dracomontana*, according to the arrangement and degree of webbing. Such sites are all around the 2000 m a.s.l. According to Channing (op cit) the species is found on the banks of, and in, highland streams not venturing away from water as is the case with *R. angolensis.* This is contradicted by Van Dijk (op cit) who recorded the species being frequently found some distance from water.

22.5 Feeding ecology

Unknown due to the difficulty of distinguishing it from *R. angolensis*.

22.6 Reproduction

According to Channing (1979), *R. dracomontana* breeds throughout the year with the exception of those areas which may be snowed up or frozen during winter. It lays *c.* 150 eggs at a time in shallow, calm water. The eggs are deposited singly or in small clumps, loosely spread on the bottom where they gather particles of sand and mud, becoming well camouflaged. No details are known of the subsequent rate of development. Van Dijk (op. cit) records finding eggs on an algal mat, in a stream with slow-flowing water a few centimetres deep and less than a metre wide. He also found small adults near the confluence of the Malibamatso and Khohlo Ntso Rivers.

22.7 Flow related aspects of the lifecycle.

According to Channing (loc. cit), the Drakensberg river frog requires pools and slow flowing water to breed in. No details of preferred flow rate are known.

22.8 Anticipated sensitivity to changes in flow regime

Any activity which may change the flow rate of a stream or river particularly at critical stages when the eggs have been laid or young tadpoles are present, are likely to impact on the survival rate of the species.

23 *RANA VERTEBRALIS* (AQUATIC RIVER FROG)

23.1 Description

A large river frog, reaching 140 mm snout-vent length. The Aquatic river frog is characterised by a squat appearance with the head having a rounded snout, an umbraculum in the eye, short stout limbs, total webbing, and a skin with small scattered warts. In colour the species is grey-brown to brown, with a darker interorbital bar, and small, poorly defined darker blotches on the back. Below white, with grey reticulations under the throat, chest and abdomen.

23.2 Distribution and abundance

Endemic to Lesotho and adjacent Kwazulu-Natal. No details of abundance have been recorded, but the species appears to be widespread in Lesotho and was recorded at several IFR Sites.

23.3 Conservation status

Endemic. Not threatened.

23.4 Habitat and microhabitat

Found in streams, rivers, ponds and other available water bodies at altitudes from 1800-3000 m a.s.l. in open grassland. Spends a considerable amount of time submerged, and is able to breathe through its skin (Lambiris 1988b), but also appears to emerge from the water and lie up under the shelter of overhanging vegetation, along the banks. According to Wager (1986) specimens up to 75 mm in size were found hiding under stones or water plants in swampy areas. He found adults in swift flowing streams using rocks on the stream bed as refuges. Both adults and tadpoles have been observed swimming about under ice, indicating a tolerance to low temperatures. According to Channing (1979) these frogs remain on the banks of, or in streams at high altitudes, and do no frequent vegetation away from water.

23.5 Feeding ecology

The species is euryphagous, feeding on a variety of prey according to the size of individuals. Mostly invertebrates are eaten but adults having been recorded feeding on gastropods, crabs, frogs and in captivity even mice. According to Channing (1979) crabs ca 30 mm in diameter were consumed underwater by these frogs, in captivity.

23.6 Reproduction

It appears that the species breeds throughout the year with the possible exception of the winter months. Like that of the other river frogs, the eggs are deposited in quiet, shallow water with a sandy to stony bottom (Lambiris 1988a), and attached to vegetation or to the rocky substrate (Channing 1979). No details of incubation are known. Wager (1986) considers that the tadpoles are rheophilic, having found tadpoles of all stages and young frogs in clear, cold streams on top of the Drakensberg. This is substantiated by Van Dijk (1996) who recorded finding tadpoles in most torrential streams, as well as along the rivers.

23.7 Flow related aspects of the lifecycle

No details of flow requirements are known, with the exception that the frogs occupy a variety of habitats from standing to flowing water and appear to be stenotopic (Channing 1979). There are conflicting opinions concerning the flow tolerances of tadpoles, indicating that they occupy slow moving to fast flowing water, and could be classed as rheophilic (Van Dijk 1996), at least along the tributaries of the main rivers in the study area.

23.8 Anticipated sensitivity to changes in flow regime

The eggs appear to require standing to slow-moving water, and this stage appears to be critical for reproductive success. Any discharge of water that affects flow rate may adversely affect ovum survival.

24 *PHRYNOBATRACHUS NATALENSIS* (COMMON PUDDLE FROG)

24.1 Description

A small frog reaching up to 32 mm snout-vent length. A robust frog with short limbs and a warty skin. Webbing on feet, with 2-3 phanges of 4th toe free of web. Variable in colour being brown,olive brown to greyish, uniform or frequently with a narrow to broad, yellow, brown to green vertebral stripe. Ventrally white with throat light to dark grey.

24.2 Distribution and abundance

Widespread in southern Africa (Passmore & Caruthers 1995).

24.3 Conservation status

Not threatened.

24.4 Habitat and microhabitat

Found wherever there is water for any length of time, in grassland to open woodland, at altitudes of up to 1800 m. Usually in close proximity to water such as quiet pools and backwaters along rivers and streams, as well as ponds, ephemeral puddles
and even marshes.

24.5 Feeding ecology

Feeds on invertebrates including ants, termites, spiders and grasshoppers (Jacobsen 1982).

24.6 Reproduction

The Common puddle frog breeds during the summer months, from late September to middle February (Balinsky 1969), laying from 400 - 800 eggs at a time, usually in quiet shallow water mostly with some emergent vegetation. The eggs form a compact raft at the surface of the water among aquatic vegetation. The eggs hatch within 3-4 days (Wager 1986). According to Wager (1986) and Lambiris (1988b) metamorphosis takes about one month.

24.7 Flow related aspects of the lifecycle

No information exists concerning flow requirements. It appears that although relatively eurytopic, the species is dependent on standing or slow moving water for reproductive success.

24. 8 Anticipated sensitivity to changes in flow regime

Apart from frequent and abrupt changes in the flow regime, which could affect egg and tadpole survival, it is unlikely that the species will be affected by changes.

PART 7: BIO-PHYSICAL FUNCTIONS OF DIFFERENT ASPECTS OF THE FLOW REGIME

25 ASPECTS OF THE NATURAL FLOW REGIME THAT SHOULD BE MAINTAINED TO ADEQUATELY PROTECT PARTICULAR FEATURES OF THE ECOSYSTEM FUNCTIONING

25.1 Lowflows

Provided that the natural order of habitat availability is not substantially altered, then even at lowflows adequate habitat should be available for those amphibians and reptiles which depend on them for varied reasons.

25.2 Highflows

Highflows will provide for off-channel water bodies, which may be beneficial to amphibian reproductive success. The latter is dependent on an adequate water supply for sufficient lengths of time to enable incubation and metamorphosis to take place. The duration of such water bodies should therefore be for a minimum of six weeks but could be much longer for species such as *Rana angolensis*. However such water need to be present at the right time of the year in the case of seasonal breeders, so that reproduction can take place when environmental cues promote spawning.

With respect to releases from dams, the frequency of discharge is the key to determining what effect if any, highflows will have on the survival of species, particularly the aquatic and near aquatic taxa. These could negatively affect reproductive success. Releases will have the greatest effect on populations closest to the discharge site, such as IFR Site 1 (d/s of Matsoku Weir) and IFR Site 2 (d/s of Katse Dam).

PART 8: ACKNOWLEDGEMENTS AND REFERENCES

26 ACKNOWLEDGEMENTS

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APPENDIX 1

Appendix 1 List of the herpetofauna likely to be present in the study area (adapted from Bates 1992, Borquin & Channing 1980). ? = species recorded from the broader area, and which, provided that habitat is available, may be present within the study area.

Scientific name	Species	Common name
AMPHIBIA		
Pipidae	*Xenopus l. laevis*	Common platanna
Heleophrynidae	*Heleophryne natalensis*	Natal ghost frog
Bufonidae	*Bufo g. gariepensis*	Karoo toad
	Bufo g. nubicolus	Drakensberg toad
	Bufo gutturalis	Gutteral toad
	Bufo rangeri	Raucous toad
Microhylidae	*Breviceps maculatus*	Spotted rain frog
	Breviceps adspersus pentheri	Penther's rain frog
Ranidae	*Tomopterna natalensis*	Natal sand frog
	Rana angolensis	Common river frog
	Rana dracomontana	Lesotho river frog
	Rana fuscigula	Dusky-throated river frog
	Rana vertebralis	Aquatic river frog
	Strongylopus g. grayi	Spotted stream frog ?
	Phrynobatrachus natalensis	Common puddle frog
	Cacosternum boettgeri	Boettger's dainty frog
	Cacosternum nanum	Bronze dainty frog ?
	Arthroleptella hewitti	Natal chirping frog ?
Hyperoliidae	*Kassina senegalensis*	Bubbling kassina ?
	Kassina (Semnodactylus) wealii	Rattling kassina ?
REPTILIA		
Sauria		
Gekkonidae	*Afroedura hallii*	Hall's flat gecko ?
	Afroedura nivaria	Mountain flat gecko ?
	Pachydactylus c. capensis	Cape thick-toed gecko ?
Agamidae	*Agama a. atra*	Rock agama
Scincidae	*Mabuya capensis*	Cape skink
	Mabuya striata punctatissimus	Striped skink
	Mabuya varia	Variable skink
Lacertidae	*Nucras lalandii*	Delalande's long-tailed lizard
	Pedioplanis burchellii	Burchell's sand lizard
	Tropidosaura cottrelli	Cottrell's mountain lizard
	Tropidosaura essexi	Essex's mountain lizard

Appendix 1 cont. List of the herpetofauna likely to be present in the study area (adapted from Bates 1992, Borquin & Channing 1980). ? = species recorded from the broader area, and which, provided that habitat is available, may be present within the study area.

Scientific name	Species	Common name
REPTILIA (cont.)		
Gerrhosauridae	*Gerrhosaurus f. flavigularis*	Yellow-throated plated lizard
Cordylidae	*Pseudocordylus melanotus subviridis*	Drakensberg crag lizard
Serpentes		
Typhlopidae	*Typhlops bibronii*	Bibron's blind snake
	Typhlops lalandei	Delalande's blind snake
Atractaspidae	*Aparallactus capensis*	Cape centipede-eater
Colubridae	*Lycodonomorphus rufulus*	Brown water snake
	Lamprophis aurora	Aurora house snake
	Lamprophis fuliginosus	Brown house snake
	Lamprophis fuscus	Yellow-bellied house snake ?
	Lycophidion c. capense	Cape wolf snake
	Duberria l. lutrix	Common slug-eater
	Prosymna s. sundevallii	Sundevall's shovel-snout
	Amplorhinus multimaculatus	Many-spotted snake
	Psammophylax r. rhombeatus	Spotted skaapsteker
	Psammophis crucifer	Cross-marked sand snake
	Crotaphopeltis hotamboeia	Herald snake
	Dasypeltis scabra	Common egg-eater
Elapidae	*Homoroselaps lacteus*	Spotted harlequin snake
	Hemachatus haemachatus	Rinkhals
Viperidae	*Bitis a. arietans*	Puff adder
	Bitis atropos	Berg adder

APPENDIX 2

Appendix 2 Habitats suitable for herpetofauna thought to occur along Lesotho rivers (Adapted from Borquin 1980).

1	Stationary water such as tarns, artificial dams, ephemeral rainwater depressions.
2	Seeps, marshy areas with slow water movement; normally densely vegetated
3	Streams and rivers, annual or perennial watercourses, normally with fast flowing clear water in summer; and flowing less strongly or dry with pools of water; or completely dry in winter.
4	Waterfalls: Any sudden steep drop over rock in a water course, over two metres high.
5	Open grassy slopes and flats: Grasslands on various slopes.
6	Exposed rocky areas in grassland, either bedrock or loose rock.
7	Cliffs and boulders associated with rocky outcrops.
8	Grassland flats with woody vegetation, not forming a closed canopy.
9	Human habitation.

APPENDIX 3

Appendix 3 Habitats of Lesotho squamata thought to occur in the study area (after Borquin & Channing 1980). The habitat arrangement follows on that referred to in Appendix 2).

REPTILIA	Habitats								
Sauria	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Afroedura hallii							X		
Afroedura nivariax							X		
Pachydactylus c. capensis					X	X		X	X
Agama a. atra						X	X		
Mabuya capensis					X	X			X
Mabuya striata punctatissimus						X	X		X
Nucras lalandii					X			X	
Pedioplanis burchellii						X			
Tropidosaura cottrelli					X	X		X	
Tropidosaura essexi					X	X		X	
Gerrhosaurus f. flavigularis					X	X		X	
Pseudocordylus langi							X		
Pseudocordylus melanotus subviridis						X	X		
Serpentes	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Typhlops bibronii					X			X	
Typhlops lalandei					X			X	
Aparallactus capensis					X			X	
Lycodonomorphus rufulus	X	X	X						
Lamprophis aurora					X			X	
Lamprophis fuliginosus					X			X	
Lamprophis fuscus					X	X			
Lamprophis guttatus						X	X		
Lycophidion c. capense						X	X	X	X
Duberria l. lutrix					X			X	
Psammophylax r. rhombeatus					X	X		X	
Psammophis crucifer					X	X		X	
Crotaphopeltis hotamboeia						X		X	
Dasypeltis scabra					X	X	X	X	
Homoroselaps lacteus					X	X		X	
Hemachatus haemachatus					X	X		X	
Causus rhombeatusx					X	X		X	
Bitis a. arietans					X	X		X	
Bitis atropos					X	X		X	

APPENDIX 4

Appendix 4 Habitats of adult amphibians thought to occur in the study area (after Borquin & Channing 1980). The habitat arrangement follows on that referred to in Appendix 2)

AMPHIBIA	Habitat								
	1	2	3	4	5	6	7	8	9
Xenopus l. laevisx	X		X						
Heleophryne natalensis			X	X					
Bufo g. gariepensis					X	X		X	X
Bufo g. nubicolus	X					X			
Bufo gutturalis	X		X					X	X
Bufo rangeri	X		X					X	X
Breviceps maculatus					X			X	
Breviceps adspersus pentheri					X			X	
Tomopterna cryptotis	X		X					X	
Tomopterna natalensis	X	X						X	
Rana angolensis	X		X		X				
Rana dracomontana			X						
Rana fuscigula	X		X						
Rana vertebralis			X						
Strongylopus g. grayi	X		X		X				
Strongylopus f. fasciatus	X	X	X						
Ptychadena porosissima			X			X			
Phrynobatrachus natalensis	X	X						X	
Cacosternum boettgerix	X	X			X				
Cacosternum nanum	X	X			X				
Arthroleptella hewitti			X	X					
Kassina senegalensis	X	X			X				
Kassina (Semnodactylus) wealii	X	X			X				