An evaluation of the threat of diamond mining to the Desert Rain Frog, *Breviceps macrops*

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INTRODUCTION

The Desert Rain Frog *Breviceps macrops* belongs to a genus of strange burrowing frogs (Fig 1). They are rotund with short legs and paddle-shaped feet, and able to survive in an arid coastal desert in the Succulent Karoo Biome. Precipitation here is mostly in the form of mist, and averages 45-114 mm per year in the areas where the frog is known (Mucina et al 2006, Jürgens 2006), with occasional rainfall increasing this to at least 146 mm (Channing & Van Wyk 1987). The biology of this species was reviewed by Minter (2004).

Figure 1. The Desert Rain Frog, *Breviceps macrops*

The species is found mostly on white coastal dunes (Fig 2), which run parallel to the coast in a narrow interrupted band sometimes only 50 m wide, with occasional larger dune fields. It occurs entirely within the coastal diamond mining areas of north-eastern South Africa and south-eastern Namibia.

Figure 2. Dune habitat of the Desert Rain Frog

Diamonds are found on the bedrock, below the sand overburden. They are mined by removing the sand, hand-collecting the diamonds or mechanically removing the diamondiferous gravel, and then replacing the sand. After the sand is replaced, the vegetation does not recover naturally in these disturbed areas (Carrick & Krüger 2007). The mines around Kleinzee have been attempting to keep the topsoil separate in this process, so that it can be spread over the deeper sands when the worked-out mine is backfilled. The disturbance to the soil structure is absolute, although work is progressing to determine the best ways to rehabilitate these old mines. South African legislation enacted in 1991 (The Minerals Act) requires that the land surface be restored (Carrick & Krüger 2007). As far as I can determine, there has been no study on rehabilitating the animals on old mine sites, although almost all the Namaqualand reptiles, mammals and amphibians are fossorial, and hence threatened by large-scale soil disturbance. A history of mining and plant restoration in Namaqualand is provided by Carrick & Krüger (2007).

Current opinion is that the frog habitat is threatened by “extensive loss to strip mining” (Minter 2004), leading to population fragmentation.

The aims of this study were:
1) To determine the habitat where the species occurs, and estimate habitat loss due to mining.
2) To evaluate the success of mine rehabilitation in terms of frog re-colonization of old mines.

METHODS

Distribution

The distribution of the Desert Rain Frog was determined from Namibian records held by M. Griffin (Namibian Ministry of Environment & Tourism), with published records, supplemented with my records based on recent fieldwork. The frog occurs almost entirely within restricted diamond mining areas, so the records in this area are opportunistic, and under-represent the expected distribution.

Extent of suitable habitat

Known records were mapped on to the vegetation units of Mucina et al (2006). The assumption was made that the frogs might occur throughout the habitat as defined by vegetation units. This is a testable hypothesis.

Frogs in active mining areas

Visits were made to the active diamond mines at Kleinzee and Koingnaas. Intensive searching was carried out during the day for frog tracks in suitable sandy habitat. This species leaves distinctive tracks (Fig 3), and small mounds where it has burrowed. At night searches were confined to the white coastal dunes.

Figure 3. Tracks of the Desert Rain Frog

Frogs on rehabilitated mines

Visits were made to rehabilitated areas, which varied in age from a few months to ten years. Five transects, each with a length of 100 m were placed to cover rehabilitated mines, with a sixth in an un-mined dune valley. Ten quadrats, each 5 x 5 m, were laid out on alternate sides of each transect. These were systematically searched for signs of frogs, reptiles and other animals.

Extent of mining disturbance

Detailed maps of past and present mining activities are not readily available due to commercial considerations. However, images from Google Earth (available at http://www.google.com) were sufficiently detailed to permit the currently active mines to be recognised, and scars from prospecting pits and other disturbances identified (Fig 4). The sizes of the following areas were determined using Google Planimeter (Available at www. acme.com).

1. Areas where *Breviceps macrops* might occur (area of occupancy). This includes the white sands along the coast, extending inland for a kilometre or two.
2. Prime areas where there is a high expectation of finding the frogs. This includes all the vegetated hummock dunes along the coast, just behind the high water mark. This is a subset of (1) above.

Figure 4. Coastal dunes (Photo: Google Earth)

3. Areas disturbed by mining. This includes all mining activities occurring within area (1) above.
The coastal distribution was only ground-truthed for areas close to Kleinzee.

RESULTS

Distribution

The localities where *Breviceps macrops* have been recorded are shown in fig 5.

Extent of suitable habitat

Breviceps macrops is effectively restricted to the Succulent Karoo Biome. In South Africa it occurs in the following vegetation units (descriptions after Mucina et al 2006):

SKs1 Richtersveld Coastal Duneveld.

This is described as a broad belt of 1-12 km, from a point between the Boegoe Twins and Alexander Bay, to about halfway between Port Nolloth and Kleinzee. Up to 200 m altitude. White sands of coastal origin.

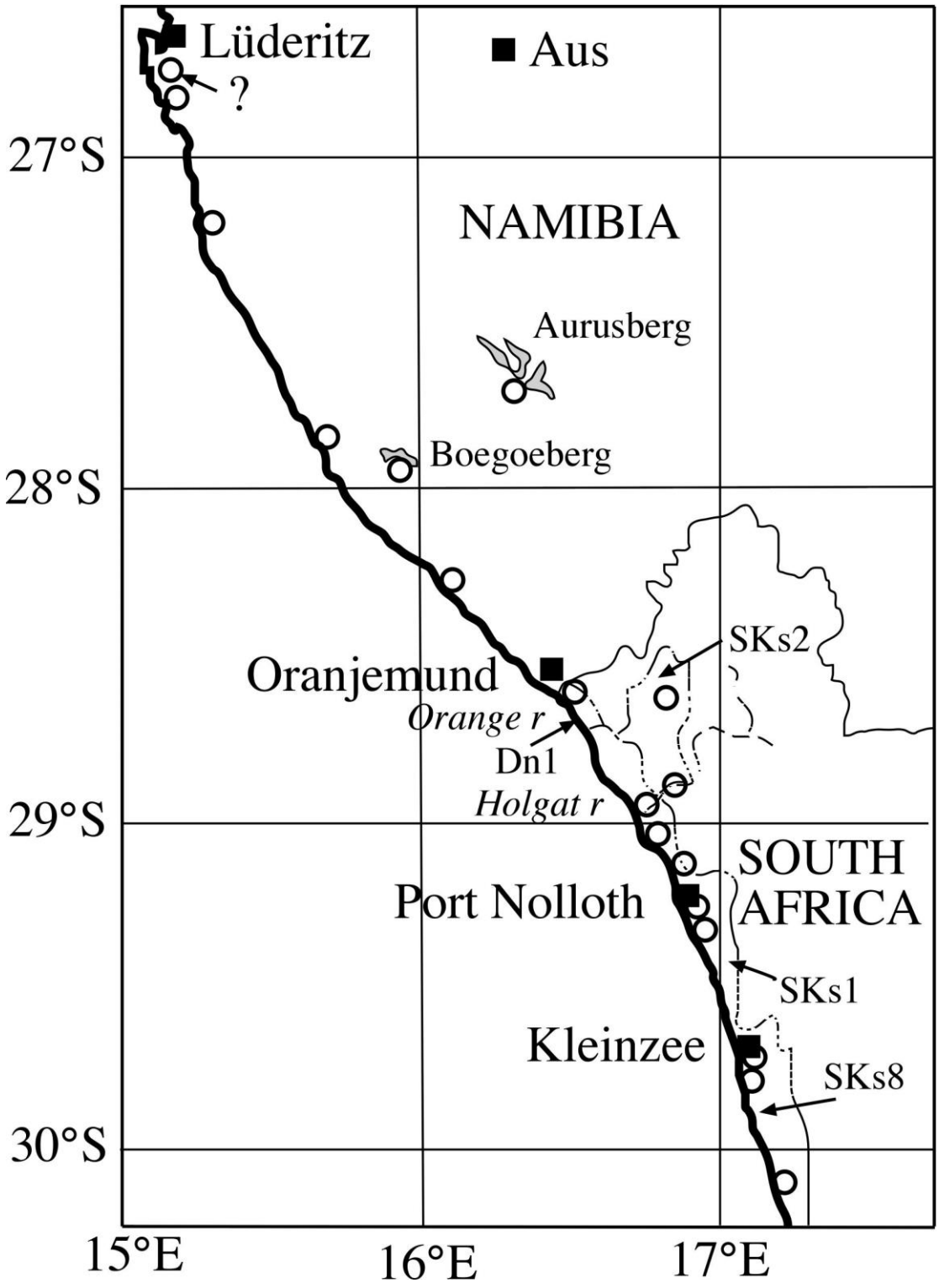

Figure 5. Localities where *Breviceps macrops* has been reported. Vegetation units (Dn1, SKs1, SKs2 and SKs8) after Mucina et al 2006. The question mark indicates the locality “Lüderitz area”.

SKs2. Northern Richtersveld Yellow Duneveld.
5-25 km wide band from Holgat River to south of Brandkaros in the north.

SKs8 s). Namaqualand Coastal Duneveld.
From south of Groenriviermond to south of Port Nolloth. The rain frog is not yet recorded from the southern parts of this unit.

Dn1 Alexander Bay Coastal Duneveld.
Sandy coastal forelands from the mouth of the Orange and Cap Voltas south of Alex.

The extent of the vegetation units where Breviceps macrops occurs are shown in Fig 5 (from Mucina et al 2006). The southern extent of the Namaqualand Coastal Duneveld unit is not shown.

Frogs in active mining areas

No signs of frogs were found in the areas that I was able to visit, in both the BMC (Kleinzee) and the Koingnaas mine. Although it was not possible to survey the whole of the active mine, much of the mine is not situated on habitat suitable for Desert Rain Frogs (see below).

Frogs on rehabilitated mines

In the 60 quadrats surveyed, totalling 1500 m^2, no signs of frogs were observed. The rehabilitated mines developed some vegetation cover after a few years, but remained sterile of small mammals, reptiles and amphibians. The undisturbed dune valley where one transect was located, was much richer in animal life, with a number of reptiles, including a tortoise, puffadder, many species of sand lizards, and a burrowing adder. These results will be reported on as part of a Namaqualand Restoration Initiative project.

Extent of mining disturbance

For this report, the distribution of *Breviceps macrops* is partitioned into the South African population south of the Orange River, and the Namibian population to the north.

South African populations

Areas where *B. macrops* is expected

Starting from Koingnaas in the south, the distribution extends northward along the coast for 193 km. The total area where the species might occur is 512.0 km^2. This is effectively the “extent of occurrence” of the IUCN.

Prime undisturbed areas:

The total area of 184.6 km^2 includes all vegetated hummock dunes above the high water mark.

Areas disturbed by mining:

Areas of active and old mines, including rehabilitated mines occuring within the area where the species is expected cover 83.3 km^2. Mining has disturbed about 16% of the expected range of the species.

The IUCN “area of occupancy” is effectively the prime undisturbed areas (184.6 km^2), but might increase once the distribution away from the coast is determined. A study has already commenced to determine how far inland the species is found.

Namibian populations
The taxonomy of the *Breviceps* records in Namibia remains questionable. Some specimens attributed to *B. macrops* may be the widespread *B. adspersus*, or perhaps *B. namaquensis*, the inland relative of *B. macrops*. This is under investigation, but for the purposes of this report, the identification of Namibian records will stand.

Areas where *B. macrops* is expected (extent of occurrence)
The species is expected at Oranjemund, on the northern bank of the Orange River, extending northwards 250 km to Lüderitz. The area of occupancy is fragmented, with a total area of 221.1 km^2.

Prime undisturbed areas (area of occupancy):
These areas are widely separated by tens of kilometers of bare rock, and total 19.8 km^2. Within the area of occupancy, areas disturbed by mining cover 41.9 km^2. This includes a continuous narrow strip just above the high water mark stretching 104 km northwards from Oranjemund.

DISCUSSION

Quality of the distribution records
The identity of the specimens reported from Namibia has not been confirmed, and this is an aspect of the problem that is presently under investigation. The distribution of the species is entirely within the restricted diamond mining areas, resulting in an under-reporting of localities.

Extent of suitable habitat
Port Nolloth receives about 200 mm of rainfall a year, but 148 days are foggy. The fog forms close to the coast, which may explain the distribution of the Desert Rain Frog in the white coastal dunes. A related species, *B. namaquensis*, appears to occur further inland in red dunes. It has been proposed that the two species may overlap, but this appears to be due to the reported type locality of B. namaquensis “Port Nolloth” (Power 1926) , which should probably be interpreted as the nearest large town.
The inland limits of *B. macrops* are presently under investigation, along with the potential overlap with *B. namaquensis*.

Active mines and frogs
Frogs are absent from the active mines near Kleinzee. This is partly due to the fact these mines follow old river-beds and fossil beach terraces, while the frogs are found on recent coastal dunes.

Rehabilitated mines
It appears that the vegetation on mines can be rehabilitated, at least as far as initial experiments show (Hälbich 2003). The results reported by Hälbich (2003) are based on work at the Namaqua Sands mine, situated just south of

the range of the Desert Rain Frog. A subsequent study (Blood 2008) pointed out that the functional diversity of the rehabilitated vegetation was a limiting factor, and there was a lack of plant species diversity. Natural recovery of vegetation does not occur on mines in Namaqualand, due to the poor rainfall and soils. The difficulties and successes of mine rehabilitation in Namaqualand are reviewed by Carrick & Krüger (2007). No fossorial reptiles or amphibians were found on rehabilited mines at Kleinzee.

Extent of mining disturbance

Mining and frog distribution overlap, but economies of mining prevent complete habitat conversion. Mines prefer to follow ancient river-beds, as well as beach terraces.

The 104 km of coastal mining in Namibia has destroyed the hummock dune system where these frogs are found. The area has been stripped to bedrock, but not backfilled, allowing sea-water to seep through and produce a series of small impoundments just above the previous high water mark. It is doubtful whether the frogs could bypass or recolonize this section of the coast.

Mucina et al (2006) report that almost 10% of the SKs1 vegetation unit (Richtersveld Coastal Duneveld) has been transformed by diamond mining. The mines in both Namibia and South Africa are coming to the end of their productive lives, but although the threats of diamond mining to this species will cease in the near future, the threats of inappropriate uses of the habitat, such as strips of housing developments along the coastline, may pose even greater threats.

Conservation status

The species is currently assigned to the VU vulnerable status of the IUCN (Minter et al 2004). This study indicates that the extent of occurrence is 733.1 km^2, with the area of occupancy 204.4 $km^{2.}$ This meets the IUCN (2000) criteria of EN endangered (B1a,biii; B2a, biii).
The results of this study suggest that the Desert Rain Frog should be re-evaluated, and placed in the Endangered category.

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