THE DRAKENSBERG ROCK-JUMPER: ECOLOGY AND GENETIC STATUS OF ISOLATED MONTANE POPULATIONS

A thesis submitted in fulfilment of the requirements

for the degree of

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of

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by

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“*I’m worrying about what you’ve got against birds*.”

– Michael Palin

The Life of Brian

DEDICATION

They say that to really understand someone, you have to walk a mile in their shoes.

The great English physicist, astronomer, alchemist and theologian Sir Isaac Newton (1642 – 1727) once famously wrote, “If I have seen further than others, it is by standing on the shoulders of giants”. What he meant was that the work he had done (in optics, mathematics, gravitation, mechanics. . .) would not have been possible if it hadn’t been for his predecessors, giants like Nicolaus Copernicus, Tycho Brahe, Johannes Kepler, Galileo Galilei, and Francis Bacon to name a few.

I would therefore like to dedicate this thesis and the work I have done for it to the unsung heroes – *the men who made the giant’s shoes*.

ABSTRACT

The Drakensberg rock-jumper (*Chaetops aurantius*) is a high-altitude passerine endemic to South Africa and Lesotho, living along a highly disrupted portion of the southern Great Escarpment from the Drakensberg highlands in the north-east to the Sneeuberg in the west, above an altitude of 1500 m. Along with the Cape rock-jumper (*C. frenatus*), this genus provides one of the stronger faunal links between the floristic biomes known as the Drakensberg Alpine Centre (DAC) and the Cape Floristic Region (CFR). Despite this, there is a significant lack of information regarding the species. The great majority of information is based on incidental observation, and no dedicated study has been undertaken.

I conducted a series of field excursions between January 2011 and November 2012 in order to explore the rock-jumper's feeding ecology, diet, habitat usage and genetic diversity. By trapping the birds, I was able to mark them individually with unique colour ring-combinations, and pluck a tail feather for genetic analyses.

Observational data reveal that birds living close to their lower altitude threshold (*c*. 1500 m) are strongly habitat specific, living in boulder fields dominated by grassy vegetation. However, in areas at higher elevations (*c*. 2000 – 2500 m) this restriction seemed to fall away, possibly as a result of farming practices in those areas – higher grazing pressure results in shorter grass and less foraging effort for the birds. They live in groups ranging from pairs to small family groups of up to twelve individuals and maintain year round territories. Territory defence takes the form of calling and displaying from a prominent rock or boulder and becomes particularly noticeable just prior to, and during, the breeding period. No colour ringed individuals were ever spotted in boulder fields outside from where they had been

initially ringed. This, coupled with the behaviour of territory maintenance, suggests a strongly sedentary lifestyle.

Genetic inferences are constrained by a small sample size (only 25 birds were caught), but results indicate that some genetic isolation is occurring – a single haplotype was exhibited in birds from across the southern Escarpment, while seven private haplotypes show that any genetic mixing is likely to be historical rather than current. Historical gene flow would most probably have occurred during the last glacial maximum (18 000 years before present), when the cooler, drier conditions which are currently restricted to high peaks would have been much more extensive, thereby decreasing the distance required for effective dispersal.

This is in agreement with the observation results, concluding that although there has been movement of birds across the southern Escarpment in the past, it does not appear to be occurring currently. However, this does leave plenty of scope for further work, particularly in the genetic diversity of the species, and in expanding the ecological observations to include the breeding biology.

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ACKNOWLEDGEMENTS

This thesis has been completed only due to the input from a number of parties, to whom I would like to say I am eternally grateful. However, one day I'll be dead, and eternity will carry on for an awfully long time. So I will merely say I am *very* grateful.

Firstly, my supervisor Adrian and co-supervisor Nigel. They have constantly provided much needed enthusiasm, insight, encouragement, constructive criticism, guidance and advice. Adrian provided me with the traps I needed to catch the birds, allowed me to access many of his journals, taught me how to handle and process birds, and came along on the initial field trips to make sure I didn't do anything stupid. He also found the funding necessary for me to attend the Pan African Ornithological Congress in Tanzania, where I presented some of this work. Nigel, quite apart from coming up with the project, ensured that I stayed funded, lent me a GPS, a camera, and showed infinite patience when I came back with a broken Pandora.

One thing that I really learnt is that field work is made much easier when it is accompanied by other people. By living in a tent on a mountain somewhere for two weeks at a time, seeing no other people and having no-one else to talk to but myself, I learnt this the hard way. I am therefore indebted to those who sacrificed their valuable time and came along with me into the field, if only to keep me from completely falling out of my pram: John Dickens, Jono Handley, Luke Bentley, Cherry Mae Smith, Matt Janks and Diane Smith. Work in the office could also get tedious, and the inimitable Bronwen May and Caroline Bell both deserve a special thanks for the countless lifts, lunches and laughs they selflessly gave away. The work in the genetics lab was certainly made much easier with the advice from Goetz Neef, Chris Kelly and Alister Barker.

If things slowed down for even a minute, I always had my family calling me and insisting they were still proud of who I was and what I was doing, even though none of them knew what a Drakensberg rock-jumper actually was. I feel that this thesis is a poor show for the unstoppable flood of love and support I have constantly felt. A huge thank-you goes to my parents, Mike and Jayne, my brother, Jason, his wife Carey, as well as my extended family.

A number of people also lent me various bits and pieces which, if not making the project possible, at least made it much easier. Pat Hulley – the speaker and walkman for bird calls; John Midgley – a GPS; Mark Galpin – a number of additional clap traps; Mel Wolmarans – a CD of bird calls; and Siya Dyaloyi – for allowing me to occasionally raid the mealworm culture that he maintained.

Two people who had nothing to do with my project nevertheless were happy to sacrifice their time to advise me, tutor me, and quite often actually haul out maps and show me – Ralph Clark and Emma Smith. Thanks to you.

The majority of field work done for this project was conducted on privately owned farms and game reserves. A huge thank-you to all the people who kindly offered accommodation and/or a chance to work on their land. **Sneeuberg**: Richard and Kitty Viljoen and the McKays (Asante Sana Private Game Reserve); Dave and Nanine Gaynor (Zuurfontein), Robin Woods and the park rangers (Mountain Zebra National Park). **Winterberg**: Niel and Wendy Scott (Glen Etive); Dave and Barbara Scott (The Hoek); Roger Bryant (Winterberg Slopes and Kingslea); Guy and Mandy Levey (Fairview). **Stormberg**: Jack and Liezel Aucamp (Leeufontain); **southern Drakensberg**: Dave Walker, Bruce and Penny (Walkerbouts Inn).

I’m also indebted to Dieter Oschadleus from SAFRING, for organising my special ringing license (Ringers number: 1575), which allowed me to catch and ring rock-jumpers within the Eastern Cape. I’d also like to thank the Rhodes University Department of Zoology and Entomology Ethics Committee for granting me ethical clearance (Tracking number: ZOOL-04-2011), enabling me to capture and work with rock-jumpers.

Finally, financial support in the form of a grant-holder linked bursary from the DST/NRD South African Biosystematics Initiative (SABI) bursary (GUN 2069059) is gratefully acknowledged.

PREAMBLE

This thesis represents the first in-depth study of the Drakensberg rock-jumper (*Chaetops aurantius*). It forms the first avifaunal study done in association with the Great Escarpment Biodiversity Project, and the first project to examine the rock-jumper outside of the Lesotho and KwaZulu-Natal Drakensberg.

Chapter 1 acts as a general introduction and is divided into two main sections: firstly, the environment in which this project was completed: namely the Great Escarpment within the Eastern Cape; and secondly, the bird this study was done on. In the first case, I provide an overview of the Great Escarpment as a whole, its origin, climate, physical characteristics and biodiversity within the Eastern Cape. In the second case, I outline the previous knowledge of the Drakensberg rock-jumper, its taxonomic status, breeding ecology, distribution and habitat requirements. The chapter concludes with the motivation and broad study aims for the project.

The main body of the thesis focuses on two significant (but poorly known) aspects of the bird's ecology: its diet and feeding (Chapter 2), and its genetic diversity (Chapter 3). Each of these chapters takes the format of a scientific paper, and is designed to stand alone with its own introduction, aims, materials and methods, results and discussion. Because of this, when reading the thesis in its entirety, some repetition of information presented in preceding chapters may occur, but an effort has been made to minimise this. The reader's indulgence is appreciated where this does occur – it has been done for the sake of re-emphasis to address a point that is considered relevant. Chapter 2 focuses on the feeding ecology, diet and habitat usage of the rock-jumper. Chapter 3 comprises an analysis of the bird's genetic diversity across the southern Escarpment in the Eastern Cape.

These chapters represent the result of eighteen field trips between January 2011 and November 2012 in all seasons, amounting to nearly 2 200 field hours and over 11 000 km’s of road travel. The 23 successfully trapped and ringed birds represent the first rock-jumpers to be caught and analysed outside of the Drakensberg mountain range.

Chapter 4 is a concluding chapter, highlighting the conclusions of the previous chapters, and includes a discussion on potential future conservation requirements of the rock-jumper and prospective areas of further study.

ETYMOLOGY

Since its description by the British Naturalist Edgar Layard in 1867, the Drakensberg rock-jumper (*Chaetops aurantius*) has been variously called a sub-species of the Cape rock-jumper (*Chaetops frenatus*), the Orange-breasted rock-jumper and the Drakensberg rock-jumper. The wording of rock-jumper also varies between a capitalised (Rock-jumper), single word (rockjumper), two words (rock jumper), hyphenated (rock-jumper) and a number of variations thereof. I follow the naming in the seventh edition of Roberts' Birds of Southern Africa (Hockey *et al*. 2005), and have called it the Drakensberg rock-jumper.

CHAPTER 1

GENERAL INTRODUCTION

The Great Escarpment of southern Africa

The Great Escarpment of southern Africa consists of a 5000km long non-continuous mountain range running from the highlands of northern Mozambique, south into Swaziland, South Africa and Lesotho, into the Western Cape where it turns north and continues through Namibia and into northern Angola (Figure 1.1) (Moore *et al*. 2009). It divides the low African coastal plains from the interior African plateau (Birkenhauer 1991; Partridge & Maud 2000).

This landscape feature was formed shortly after the break-up of Gondwana, when rifting between southern Africa and the surrounding continental masses caused the opening up of the south Atlantic and Indian Oceans, around 120 million years ago (MYA) (Partridge & Maud 1987; Meadows & Watkeys 1999; Partridge & Maud 2000; McCarthy & Rubidge 2005). The exact cause of this breakup is still a matter of some debate (McCarthy & Rubidge 2005) and suggestions have been made supporting either a large-scale mantle plume event (Burke 1996; Ebinger & Sleep 1998; Gurnis *et al*. 2000), or the development of oceanic ridges, which caused Gondwana to split apart (Moore *et al*. 2009). Once this had occurred, the southern African subcontinent underwent a number of important uplift events, caused by isostatic loading (*c*.100 MYA) (Brink & Stern 1992) and large-scale igneous intrusion events (*c*. 45-30 MYA) (Birkenhauer 1991; Burke 1996).

Once this breakup of Gondwana had taken place, the high-lying subcontinent was gradually eroded from its outer rim inwards, creating the coastal plain (Partridge & Maud 1987; Birkenhauer 1991; Moore *et al*. 2009). The majority of rivers on this plain have not incised through the escarpment, but those that have (notably the Orange, Limpopo and Zambezi rivers) are highly significant in their role of draining the inland plateau (Partridge & Maud 1987; Moore *et al*. 2009).

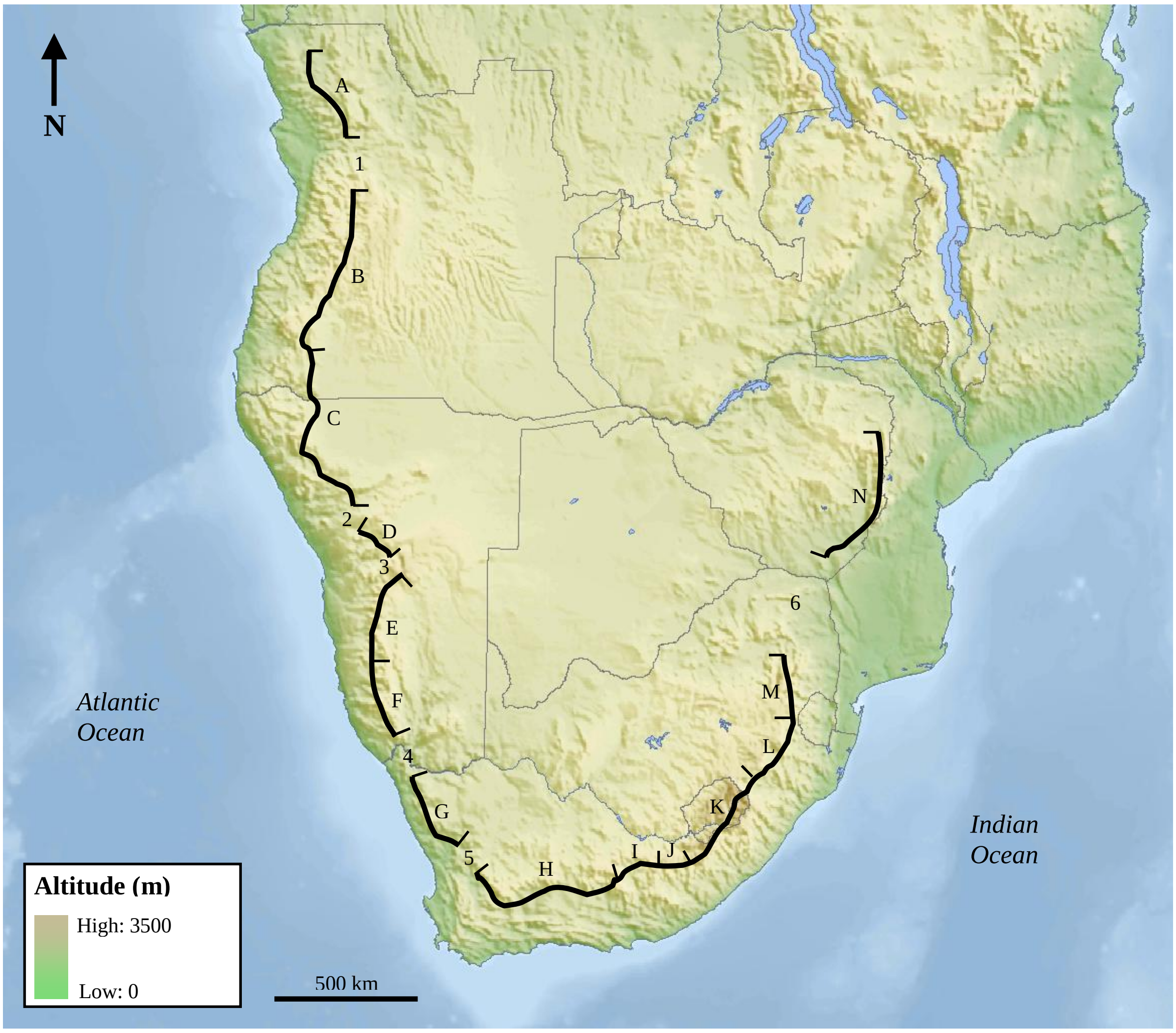

Figure 1.1: The Great Escarpment in southern Africa, indicating the principal sections of the Escarpment, relief and major intervals. Great Escarpment sections: A: Cuimba-Serra de Mocaba-Lombe; B: Bié; C: Kaokoveld; D: Erongo; E: Windhoek; F: Tiras; G: Richtersveld-Namaqualand; H: Hantam-Roggeveld-Nuweveld; I: Sneeuberg; J: Great Winterberg-Amatola; K: Stormberg-Drakensberg; L: KwaZulu-Natal Drakensberg; M: Mpumalanga-Limpopo; N: Chimanimani-Nyanga. Major intervals: 1: Cuanza River; 2: Omaruru River; 3: Swakop River; 4: Orange River; 5: Loeriesfontein; 6: Limpopo-Save Interval. After Figure 1.1 in Clark 2011 and Figure 1 (inset) in Clark *et al*. 2011c.

The Great Escarpment in the Eastern Cape

Geomorphology

The Great Escarpment within the Eastern Cape can be thought of as a southern continuation of the Drakensberg range. Indeed, the most northern part of this Escarpment section is actually the southern Drakensberg (Figure 1.2). This extends in a south-westerly direction via the Stormberg and Winterberg mountains to the Great Fish River, roughly parallel to the coastline, but lying between 70 and 130 km inland. North of the Winterberg is a low-lying area around Tarkastad. Further north of this is the Suurberg mountain range, which forms a westward arm of the Stormberg mountains and the eastern and northern watershed of the Great Fish River (Tordiffe & Botha 1981). The river itself was thought to represent an important biogeographic divide between western and eastern sections of the Escarpment in the Eastern Cape, with the western sections having closer ties with the Cape Floristic Region (Clark *et al*. 2009; Cowling *et al*. 2009). However, more recent studies, focused on the Sneeuberg mountains, have shown that this biogeographic divide is not as significant as was previously suggested (Clark *et al*. 2009; 2011a and b). The Sneeuberg mountains lie to the west of the Great Fish River, curving around the northern headwaters of the Sundays river. Since the end of the Jurassic (*c*. 140 MYA), this section of the subcontinent has seen an extended period of tectonic stability (Nicol 1988), enabling the Kei and Great Fish Rivers to incise through the Escarpment, dividing the Stormberg and Winterberg, and Winterberg and Sneeuberg respectively. The Sundays River merely drains portions of the Sneeuberg, and it will be some time before it cuts through it entirely.

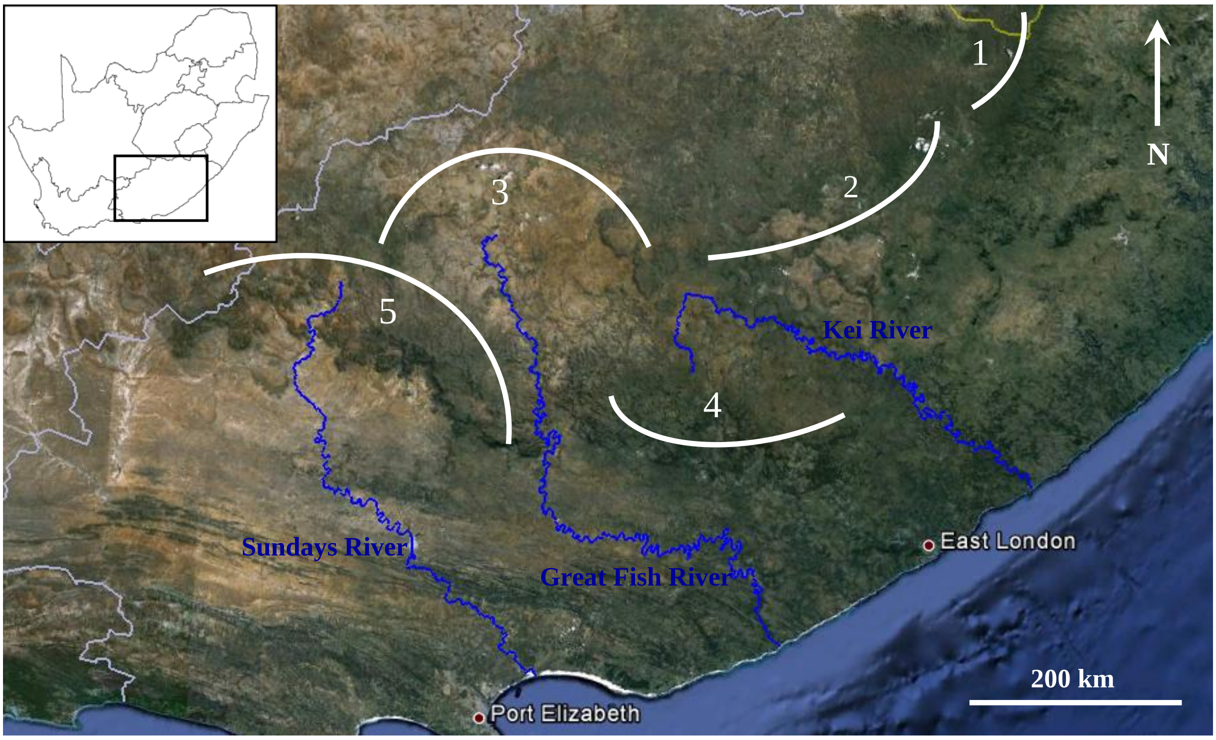

Figure 1.2: The Eastern Cape section of the Escarpment, showing topography, notable river systems and important mountain arcs. Principle mountain blocks are 1: the southern Drakensberg; 2: the Stormberg; 3: the Suurberg; 4: the Winterberg and 5: the Sneeuberg. Numbers correspond with Table 1.1. After Figure 1 in Clark *et al*. 2009 and Figure 1 in Thomas *et al*. 2002.

Table 1.1: The important mountain block areas of the Escarpment within the Eastern Cape.

Range	Principle Features	Extent	Notes
1. Southern Drakensberg	Naude's Nek Pass (2500m) Ben McDhui (3001m)	80 km	Forms the southern section of the Drakensberg Alpine Centre
2. Stormberg	Middelberg (2107m) Toringberg (2111m)	120 km	Forms southern arm of the Drakensberg Mountain Range
3. Suurberg	Toorberg (2119m)	190 km	Forms the northern mountain corridor between the Stormberg and the Sneeuberg.
4. Winterberg	Winterberg peak (2333m)	125 km	Forms the southern mountain corridor between the Stormberg and the Sneeuberg.
5. Sneeuberg	Kompasberg (2502m) Nardousberg (2429m)	200 km	Forms the catchment area and watershed of the Sundays River.

Geology

The geology of the Escarpment in the Eastern Cape is typical of the Karoo supergroup. The southern and western portions are comprised of Beaufort group shales and mudstones, interbedded with sandstone horizons, and intruded by dolerite dykes and sills of varying scales (Tordiffe & Botha 1981; McCarthy & Rubidge 2005). These intrusions are typically surrounded by aureoles of metamorphic or “baked” sediments, namely quartzite and hornfels (van Zijl 2006), and their high levels of erosive resistance compared to the surrounding rock means that they form mountain peaks and plateaus (Nicol 1988; Clark *et al*. 2012). A noteworthy feature of these high-altitude dolerite outcrops is that they are broken up by mechanical and chemical weathering into a mass of irregular and angular boulders (Watkeys 1999; Clark *et al*. 2009). This group was laid down during the mid- to late Permian (*c*. 260 MYA), by large meandering rivers flanked by extensive floodplains that were periodically inundated during large-scale flooding events (McCarthy & Rubidge 2005). In the north and eastern parts of the Eastern Cape Escarpment, the geology is somewhat more complex, and comprises (in ascending order) Molteno, Elliot, Clarens and finally Drakensberg groups (Holzforster 2007). These represent a period of gradual aridification of this part of the sub-continent, and terminate with the massive basaltic outpouring *c*. 180 MYA, creating the Drakensberg highlands (Nicol 1988; McCarthy & Rubidge 2005).

Climate

Within the Eastern Cape, the Escarpment defines a dramatic change in altitude between the coastal lowlands and the interior. Because of this, it delineates a sharp change in weather patterns as well, dividing the warm, humid coastal areas from the drier areas further north (Birkenhauer 1991). The section of the Southern Escarpment that lies within the Eastern Cape also straddles the transition zone between the arid west and moist east (Kopke 1988; Thomas *et al*. 2002; Boardman *et al*. 2003; Clark *et al*. 2009; 2011c).

Wind is the principle driver of weather conditions in the region, and alternates between south-easterly and north-westerly in the summer and winter respectively (Desmet & Cowling 1999). Orographic rain is brought in this way from the west, and falls on the region as a result of the diminishment of the Cape Fold Mountains (Desmet & Cowling 1999). Rainfall peaks in the summer, but January is typically the wettest month in areas east of the Great Fish River interval (Hoare & Bredenkamp 1999, 2001; Thomas *et al*. 2002), and March is wettest in areas to the west (Van der Walt 1980; Jackson & Bernard 2005; Clark *et al*. 2009, 2011a). Cut-off lows creating rain and snowfall are also important forms of precipitation in the winter (Jackson & Bernard 2005; Clark *et al*. 2009). Importantly, high peaks in the area (such as those shown in Table 1.1) can have their own micro-climates (which are typically slope-aspect dependent), and have periodic spells of very low temperatures during cold fronts, or in winter (Kopke 1988; Watkeys 1999; Clark *et al*. 2009).

Fauna and Flora

The Great Escarpment has been described as an important corridor and acts as a refugium for biological diversity (Clark 2010), as well as hosting more than half of the sub-continent's endemic centres (Clark *et al*. 2009, 2011b). This is due to the formation of "nodes of high local endemism" by environmental and physical factors (Clark *et al*. 2011b, p. 2544).

The majority of the endemic vertebrate fauna of the southern Escarpment is not restricted to that region, but shares notable ties with the Drakensberg highlands, the Highveld plateau and/or the KwaZulu-Natal midlands further east (e.g. Blue Korhaan *Eupodotis caerulscens*, Buff-streaked Chat, *Oenanthe bifasciata*, Dark-footed Forest Shrew *Myosorex* *cafer*, Plaintive Rain Frog *Breviceps verrucosus* and the Long-toed Tree Frog *Leptopelis xenodactylus*), and – to a lesser extent – the Cape Escarpment and Cape Floristic Region to the west (such as the Cape Mole-rat *Georychus capensis*, the Cape rock-jumper *Chaetops frenatus* and the Forest Buzzard *Buteo trizonatus*) (Channing 2001; Hockey et al. 2005; Skinner & Chimimba 2005). The Mountain Pipit (*Anthus hoeschi*) breeds in the Drakensberg section of the Escarpment, but is assumed to migrate to south-central Africa for the winter (Hockey *et al*. 2005). Other species, such as the Black-fronted Bush-shrike (*Telophorus nigrifrons*) and the Orange Ground-Thrush (*Zoothera gurneyi*) occur more widely in the Afromontane region in Africa, but in South Africa are restricted to this Escarpment (Hockey *et al*. 2005). Although invertebrate groups are highly under-represented in this case, current knowledge does suggest that endemism on the Escarpment is also high (Kirk-Spriggs & McGregor 2009; Clark *et al*. 2011b; Fearon 2011). The Eastern Cape Escarpment forms the transition area for three insect biomes – the Karoo zone to the west, the grassland zone to the north and east, and the bushveld zone along the coast to the south (Picker *et al*. 2004)

In general, flora in this part of the southern Escarpment can be divided into three main classes – high altitude or alpine (peaks, plateaux, outcrops etc.), valleys, and low-lying areas. Low-lying areas (1000-1400m) are dominated by Albany thicket (Clark *et al*. 2009) and consist of dry grassland, karroid dwarf shrubland and *Acacia* savanna (Hoare & Bredenkamp 1999). Of the three, this zone is most affected by farming practices since the initiation of European settlement in the late 18th century (Meadows & Meadows 1988; Clark *et al*. 2011a). Land use in these areas has been primarily stock grazing, and these high stocking densities have caused gully and sheet erosion as well as notable destruction of wetlands (Boardman *et al*. 2003; Clark *et al*. 2009). Valleys west of the Great Fish River typically form refugia for forest and woodland species (*Celtis africana*, *Kiggelaria africana* and *Olea europaea*), as well as ferns (*Asplenium aethiopicum*, *A. monanthes*, *Blechnum attenuatum* and *Cystopteris* *fragilis*) along water courses (Clark *et al*. 2009; 2011a). High altitude areas (above 1600m) in the Sneeuberg are dominated by forbs and geophytes as well as grasses (*Ehrharta calycina, Melica decumbens, Merxmuellera macowanii, Tenaxia disticha, Tetrachne dregei, Karroochloa purpurea*), and specialist grasses growing at the base of cliff lines (*Festuca* spp. and *Brachypodium bolusii*) or in moist cracks and on high peaks (*Pentaschistis aroides*) (Clark *et al*. 2009; 2012). East of the Great Fish River, floristic patterns in the Winterberg and Stormberg show greater affinities with the Drakensberg (although the eastern parts of the Sneeuberg – the Boschberg – have significant affinities with the Winterberg mountains (notably *Watsonia pillansii*), as shown by Clark *et al*. 2011a). Montane grasslands here are dominated by grasses (*Digitaria argyrograpta*, *Tragus koelerioides*, *Tenaxia disticha*, *Themeda triandra*, *Eragrostis curvula*, *E. chloromelas*, *Aristida diffusa* and *Cymbopogon excavatus*), and dotted with shrubs (*Rhus discolor* and *R. dentata*), and forbs (*Helichrysum nudifolium*) (Hoare & Bredenkamp 1999, 2001; Carbutt & Edwards 2006). At these high altitudes, structural classes between vegetation are most sharply defined by climatic factors (principally rainfall), altitude, substrate and slope inclination and orientation (Hoare & Bredenkamp 1999, 2001; Clark *et al*. 2009).

The long, thin nature of the Great Escarpment, coupled with the fact that it traverses some very steep environmental gradients and is divided by bisecting rivers and other intervals has raised conservation concerns (Clark et al. 2011b). Invasive flora have become a noted problem: large areas of the summit plateau of the Groot-Bruintjieshoogde and the Boschberg in the Eastern Sneeuberg are covered by *Nassella trichotoma*, a South American grass species (Clark *et al*. 2011a). Signs of this wind-distributed plant are becoming apparent further west in the Sneeuberg, and – critically – across the Great Fish River to the east, in the Winterberg. Black wattle (*Acacia mearnsii*) and Patula pine (*Pinus patula*) were introduced by European settlers, and have since become problematic (Clark *et al*. 2011a), as well as Sweet Briar

(*Rosa rubiginosa*) and Elderberry (*Sambucus nigra*) (Clark *et al*. 2009). Awareness about the threat presented by invasive plants (particularly to wetlands, which act as drainage channels in the landscape: Hoare & Bredenkamp 1999) is increasing, and a number of farms have begun rehabilitation programs. Secondly, there is an increasing trend of converting farms into game reserves, and allowing them to undergo processes of re-wilding (Clark *et al*. 2011a)

Previous Research and the Great Escarpment Biodiversity Program

This southern section of the Great Escarpment has been an area of recent research, following the work of Clark (2010). His doctoral thesis, as well as associated and later publications (Clark *et al*. 2009; 2011a, b and c; 2012) showed that the southern Escarpment (comprising the mountain blocks shown in figure 1.2 and table 1.1 as well as the Nuweveldberge and Roggeveldberge further west) is poorly explored both in terms of fauna and flora. As a result of this the Great Escarpment Biodiversity Program (GEBP) was established by researchers at Rhodes University in 2009, in order to focus research on this “rich, but poorly explored” area (Clark *et al*. 2011c, p. 13).

Soon after its inception, the GEBP initiated a number of faunal projects, in order to assess the role these mountains play as genetic corridors for various animal groups, and compare them to the patterns shown by the known flora.

Apart from Clark’s PhD, two MSc theses have been completed to date, by Fearon (2011) and Kok (2011)[1]. Other notable contributors are Chris Kelly, John Midgely (whose PhD has recently been submitted), Michael Cunningham and Gareth Keevey.

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[1] Part of this thesis was subsequently published as Kok *et al*. 2012.

The Drakensberg Rock-jumper

Taxonomic Status

The Drakensberg rock-jumper (*Chaetops aurantius*) was first described and published by the British naturalist Edgar Layard in 1867, although the first text about it appeared in January 1863, when a Graaff-Reinet local, Mr. J. O'Reilly, wrote about its occurrence "in some abundance in the mountains near Graaff-Reinet" (Layard 1867, p.126). He placed the genus in the Turdidae family (principally occupied by the thrushes, chats and their allies).

Up until the late 1960's, *C. aurantius* was considered to be a subspecies of *C. frenatus*. Indeed, a news sheet of the Natal Bird Club for December 1969 contains a number of letters, all referring to "Rockjumpers, *Chaetops frenatus*" in the Drakensberg. Hall & Moreau (1970) suggested that *frenatus* "may be an incipient species" (p.114) but Winterbottom (1973) gave *aurantius* "full specific rank" (p. 144). The debate, however, lasted until the 1980's, when Irwin (1985) compared the two species, saying "these two allopatric populations seem very similar and differ only in matters of degree and for present purposes. . . are regarded as conspecific" (p. 99). Irwin (1983) had also discovered that the Timaliidae (Babblers) had a particular growth structure of tail feathers, which the rock-jumpers exhibited. This, coupled with a rump "profusely feathered and soft" (Irwin 1985 p. 99), led him to move *Chaetops* in with the Babblers. Importantly, Olson (1984) showed conclusively on the basis of syringeal morphology that the genus did *not* belong in the Turdidae, as Layard had originally thought. Irwin (1985) agreed, but suggested that "its thrush-like [beak] appearance and rupicolous habitat point to long isolation. . . the genus must be regarded as long isolated and probably relict" (p. 99).

The groundbreaking work of Sibley & Alquist (1990) injected molecular systematics to the rock-jumper taxonomy debate. Although they only had samples of *frenatus* (and insisted on calling it the Rufous rock-jumper), they placed the genus in the Picathartidae family, along with the genus *Picathartes*, a west-African group of rockfowl. Combining this with skeletal data, they concluded that "*Chaetops* is probably a member of the Corvida" (p. 627).

By now, *Chaetops* had been moved from the Turdidae, through the Timaliidae, into the Picathartidae, and finally removed from the Passerida altogether. As Craig (1991) pointed out "I'm sure the debate will continue" (p. 17). Olson (1998) even discussed moving it to the Sylviidae. Since then, the Picathartidae have gradually moved out of the Corvids, into a position somewhere just outside the Passerida (Barker *et al*. 2002), and then shifted to occupy "the deepest branch within Passerida" (Ericson & Johansson 2003 p. 132). This was due to the discovery that all Passerines exhibit a particular codon in the *c-myc* gene that both rock-jumpers and the other Picathartidae have (Ericson & Johansson 2003). Despite this, Barker *et al*. (2004), Beresford *et al*. (2005) and Jønson & Fjeldså (2006) have all placed the Picathartidae *between* the Corvids and Passerida.

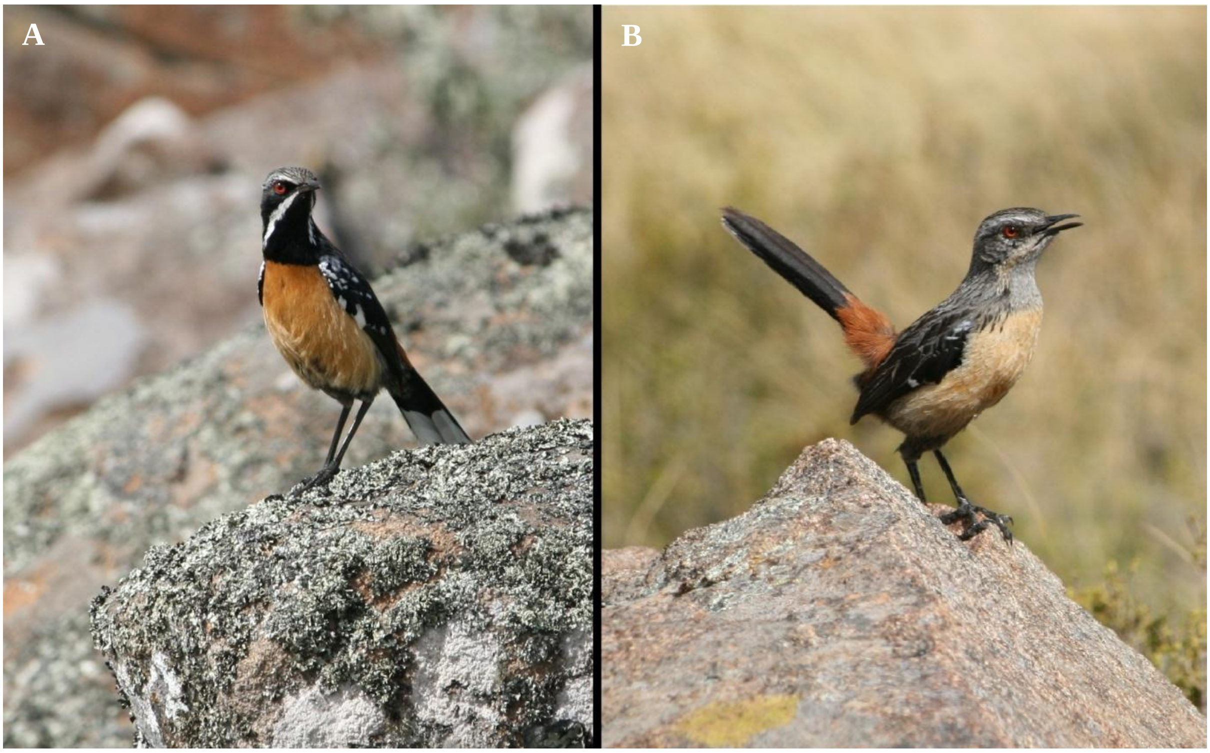

Figure 1.3: The Drakensberg Rock-jumper (*Chaetops aurantius*). (A) Male and (B) Female.

Physical Description

The Drakensberg rock-jumper is a medium sized bird, with a length of between 20 and 22 cm in length (Hockey *et al*. 2005), weighing between 47 and 60 g (pers. obs.; Voelker 1999). The sexes differ slightly in colouring (Layard 1867; Tait 1948; Hockey *et al*. 2005). In the male the upper parts of the head and upper back are streaked grey-brown. The shoulders are dark, but flecked with white, and the wings are white tipped on the underside, a feature which is quite prominent when the bird flies. The tail is rounded, and also white tipped (Figure 1.3A), which is easily seen when the bird flies or displays. The throat is black with white moustachial stripes. The breast is sandy-orange, becoming slightly paler on the belly. The lower back and rump are loosely feathered and rufous-red. The female (Figure 1.3B) differs from the male in that it has a paler breast, and its face and throat are pale grey, rather than black. The stripes on its throat and above its eyes are also grey, as well as the flecks on its shoulders. In adults the eyes are orange-red (Tait 1948; Hockey *et al*. 2005).

Territories, Breeding and Nesting

Rock-jumpers are known to live in pairs or small family groups on territories that they occupy year-round (Collins 1969; Holmes *et al*. 2002; Hockey *et al*. 2005). Their breeding season is usually from October to November, but egg-laying may occur any time from August to February (Tarboton 2001; Hockey *et al*. 2005). The nests are grass, cup-shaped, and built in a grass tussock, usually up against a large rock or boulder (Tait 1948; Tarboton 2001; Holmes *et al*. 2002). Clutches are typically three eggs, occasionally two, and are incubated by both sexes (Tarboton 2001). The incubation and fledging period have not been recorded in *C. aurantius*, but in the Cape rock-jumper (*C. frenatus*) are 19-21 days and 18-21 days respectively (Holmes *et al*. 2002).

Distribution and Habitat

The Drakensberg rock-jumper is endemic to South Africa and Lesotho, and is found in the mountains of western Kwa-Zulu Natal, Lesotho, parts of the eastern Free State (along the Lesotho border), the Eastern Cape, and the north-eastern extremes of the Western Cape (Hockey *et al*. 2005, Figure 1.4).

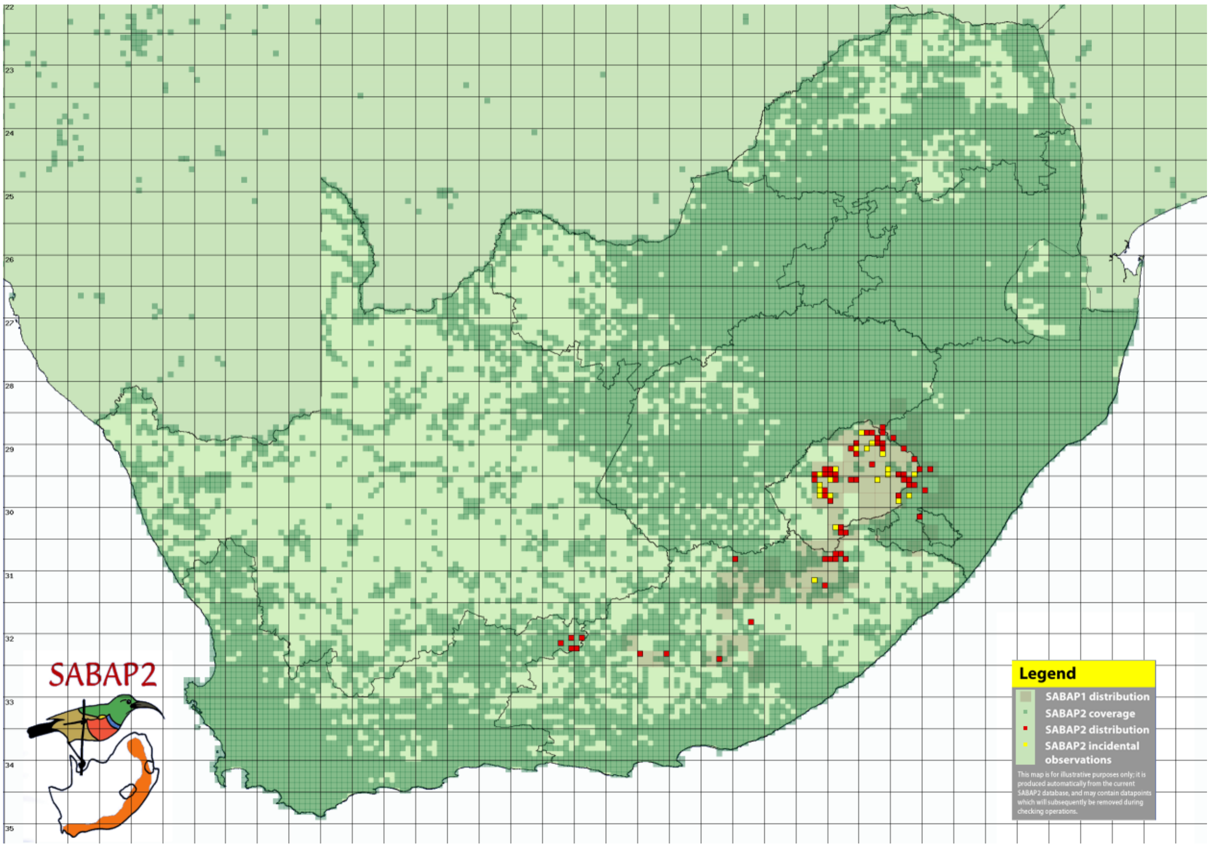

Figure 1.4: The South African Bird Atlas Project (SABAP) 2 map, showing the distribution of the Drakensberg rock-jumper in South Africa and Lesotho. Yellow dots depict incidental observations of the species, while red dots show the confirmed SABAP 2 distribution of the rock-jumper.

The bird is only present above an altitude of 1500 m (Barnes 1969; Coghlan 1969; Symons 1969; Craig 1991; Little & Bainbridge 1992; Bonde 1993), and in a fairly restricted habitat – boulder fields dominated by grassy vegetation (Hockey *et al*. 2005). These boulder fields are typically remnants of the dolerite intrusions of the Permian, 200 MYA (van Zijl 2006), which have subsequently been exposed and eroded. Since these boulder fields typically exist at high altitudes (which may be snow-covered in winter), and have relatively poor soil cover, they are thought to be formed through mechanical weathering such as freeze-thaw action and frost shattering (Watkeys 1999).

Figure 1.5: Typical rock-jumper habitat – a mountain-top boulder field on a grassy slope at Asante Sana Private Game Reserve.

Motivation and Broad Aims

The aims of this project were to collect new biological information on the Drakensberg rock-jumper, as it is a relatively poorly known species, and to define its habitat selection within the southern Escarpment of the Eastern Cape. The majority of published prior knowledge of the bird stems from incidental field observations (Tait 1948; Barnes 1969;

Coghlan 1969; Collins 1969; Symons 1969; Du Plessis 1990; Craig 1991), or deals with its phylogeny (see above) and is based on Cape rock-jumpers (*C. frenatus*) samples (Sibley & Ahlquist 1990; Barker *et al*. 2002; Ericson & Johansson 2003; Barker *et al*. 2004; Beresford *et al*. 2005). An example of this lack of knowledge is that Little & Bainbridge (1992) and Hockey *et al*. (2005) both suggest that rock-jumpers undergo short altitudinal migrations, dropping down to lower elevations in winter. However, this does not appear to be supported by any definitive, quantitative data (such as colour ringing birds at high altitude in the summer, and then observing those individuals at low altitude in the winter), putting doubt into the potential reliability of such information.

Since the basic ecology of the bird is therefore poorly known and understood, this raises questions with particular regard to how it uses its habitat. For this study, special attention was given to its territory maintenance and defence as well as diet and foraging and its movements and adaptations in this regard (Chapter 2). Secondly, since no genetic assessment on the bird has ever been performed, a phylogeographic component was also undertaken, in an effort to assess its genetic diversity across the fragmented section of the southern Escarpment that lies within the Eastern Cape (Chapter 3). In floristic terms, this part of the Escarpment forms an important corridor (Clark *et al*. 2011c). Altogether, the area does show significant levels of endemism, but adjacent mountain blocks do show important affinities (Clark *et al*. 2009; 2011a; Clark 2010). However, recent data suggests that small mammal (particularly the genus *Otomys*) samples collected in the Drakensberg and Sneeuberg highlands are genetically distinct, suggesting no genetic exchange has occurred for some time (Davidson 2009; Mataruse 2010). Does the high-altitude avifauna exhibit similar genetic isolation, or is there exchange between apparently isolated populations? The Drakensberg rock-jumper is an ideal candidate on which to test this, as with the Cape rock-jumper, it forms one of the stronger faunal links between the DAC and the CFR (Clark *et al*. 2009).

CHAPTER 2

OBSERVED BIOLOGY, BEHAVIOUR, FEEDING ECOLOGY AND HABITAT USAGE

Introduction

The Drakensberg Rock-jumper (*Chaetops aurantius*) is endemic to the central mountains of South Africa and Lesotho. There is little known about the bird in terms of its basic biology, population status, social interactions, breeding, territory size and maintenance and feeding ecology. The majority of information that has appeared in the published literature is based on opportunistic observations and not backed by any quantitative data collection (Barnes 1969; Coghlan 1969; Collins 1969; Fey 1969; Symons 1969; Winterbottom 1973; Du Plessis 1990; Little & Bainbridge 1992; Osborne & Tigar 1992; Bonde 1993). This is not surprising, given that the bird in question lives at high altitude in largely rural and remote areas.

The aims of this chapter are to provide a broader understanding of this little known species, particularly with regards to its territorial behaviour and its feeding ecology.

Materials and Methods

Study Sites

The majority of observations were made at Asante Sana Private Game Reserve, 40 km east of Graaff Reinet in the Eastern Cape (Figure 2.1), with incidental observations being done at other sites across the Eastern Cape (see below). Asante Sana lies close to the middle of the Sneeuberg mountain range (Figure 2.2), and near the western limit of the rock-jumpers range (Clark *et al*. 2012).

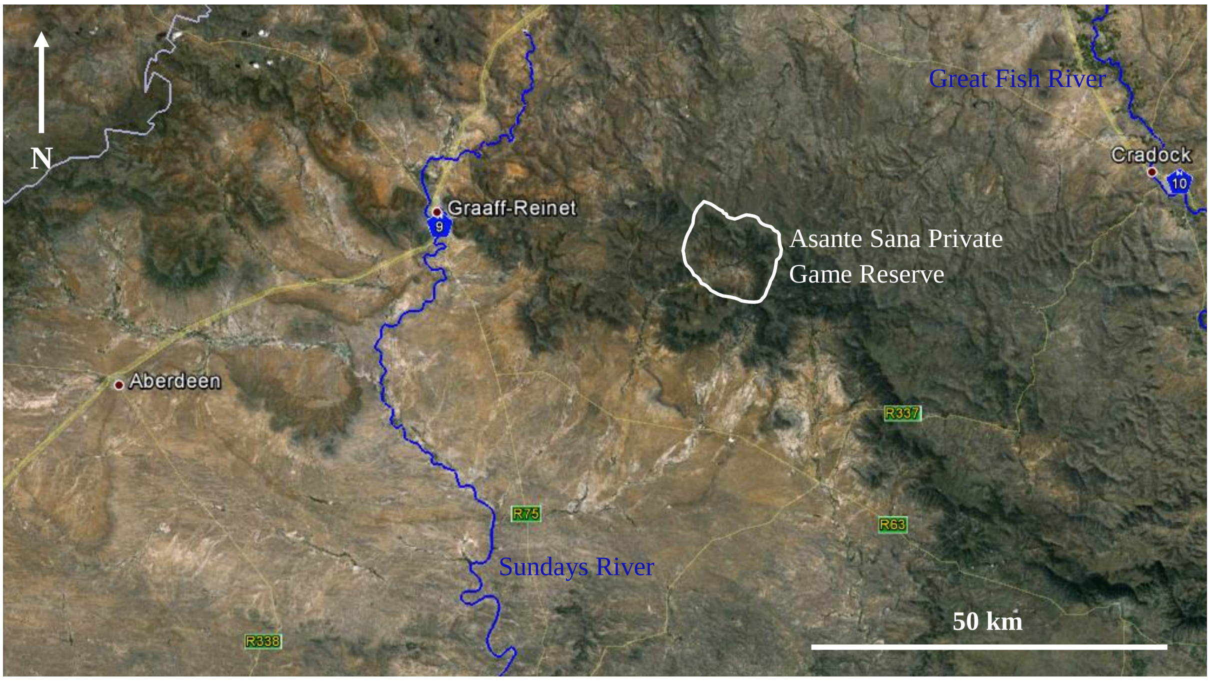

Figure 2.1: The location of Asante Sana within the Eastern Cape.

The Sneeuberg mountain range lies in a climatic transition zone, with annual rainfall increasing from west to east (Van der Walt 1980; Clark *et al*. 2009). Asante Sana receives most of its rainfall during the summer and autumn months (Kopke 1988; Boardman *et al*. 2003; Kok 2011; Kok *et al*. 2012). Precipitation in the area is highly localised, with higher peaks generally receiving more rain than lowland areas (Clark *at al*. 2009; Kok *et al*. 2012), although this is strongly dependent on slope aspect and peak height (Van der Walt 1980; Kopke 1988; Clark *et al.* 2011a).

The geology of the Sneeuberg is principally Beaufort Group shales and mudstones, interbedded with sandstone layers (Boardman *et al*. 2003; McCarthy & Rubidge 2005). These have been intruded by dolerite dykes and sills (Nicol 1988; McCarthy & Rubidge 2005), which – due to their erosion resistance – typically form the peaks of hills and mountains in the form of plateaus and boulder fields (Clark *et al*. 2009).

Vegetation in the Sneeuberg either falls into the Nama-Karoo or Grassland biomes (Mucina & Rutherford 2006; Clark *et al*. 2009). The high-altitude areas of Asante Sana lie in the Grassland biome, and are dominated by *Tenaxia disticha*, *Eragrostis chloromelas*, *Aristida congesta*, *Targus koelerioides*, *Themeda triandra* and *Karroochloa purpurea* (Mucina & Rutherford 2006; Clark et al. 2009; Kok 2011).

Marking Birds and Data Collection

A total of eighteen field trips were conducted to nine field sites, ranging from the Kamdebooberge region of the western Sneeuberg, to the Naude’s Nek area of the southern Drakensberg (Figure 2.2).

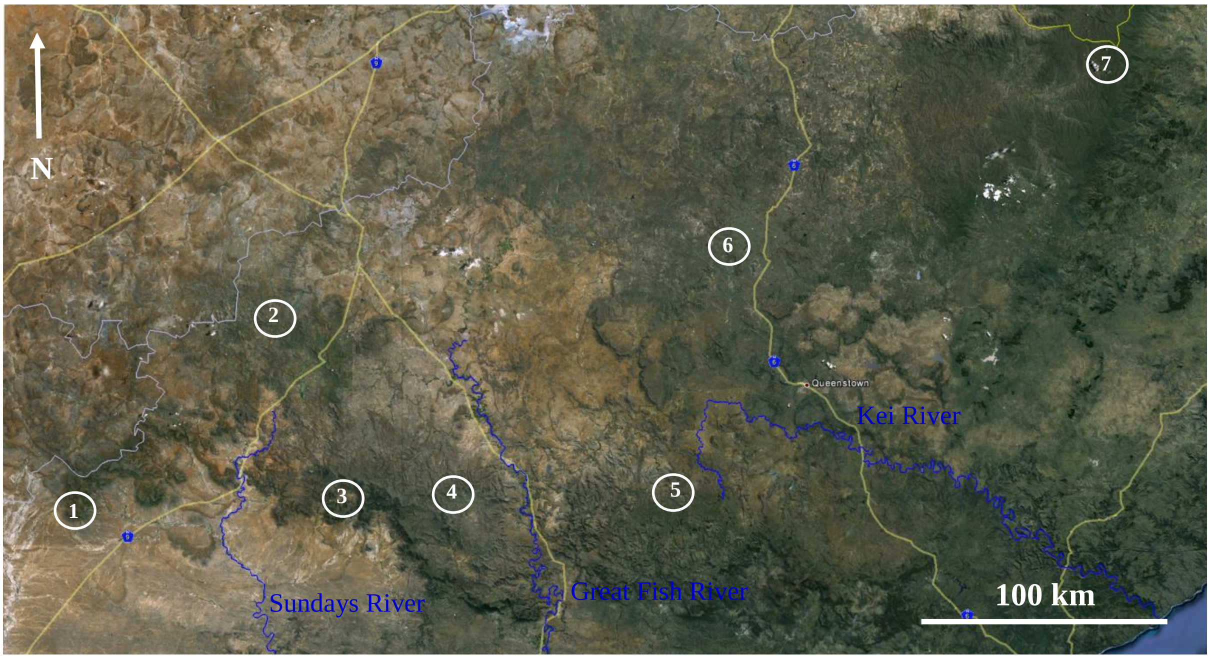

Figure 2.2: The field sites used for this study. 1: The Kamdebooberge; 2: Zuurfontein farm (north-east of the main Kompasberge Peak); 3: Asante Sana Private Game Reserve; 4: Mountain Zebra National Park; 5: The Winterberg area (including the main Winterberg Peak, Klein Winterberg and Katberg Pass); 6: Leeufontein Farm (between the towns of Molteno and Dordrecht); 7: The Naude's Nek Pass area.

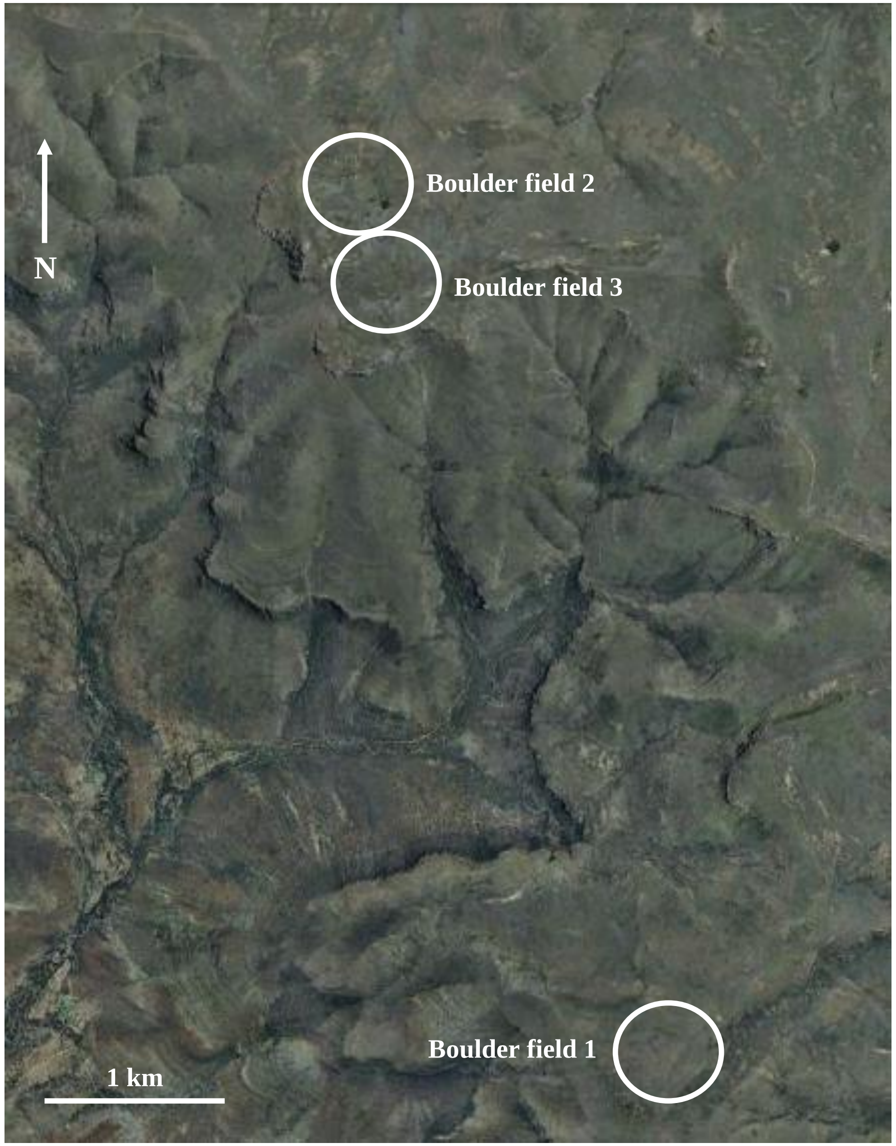

Figure 2.3: The boulder fields in Asante Sana. GPS co-ordinates for boulder field 1 are S 32°18'09.8'' E 25°02'15.2''; boulder field 2 are S 32°15'43.1'' E 25°01'30.5''; and boulder field 3 are S 32°15'55.1'' E 25°01'31.4''.

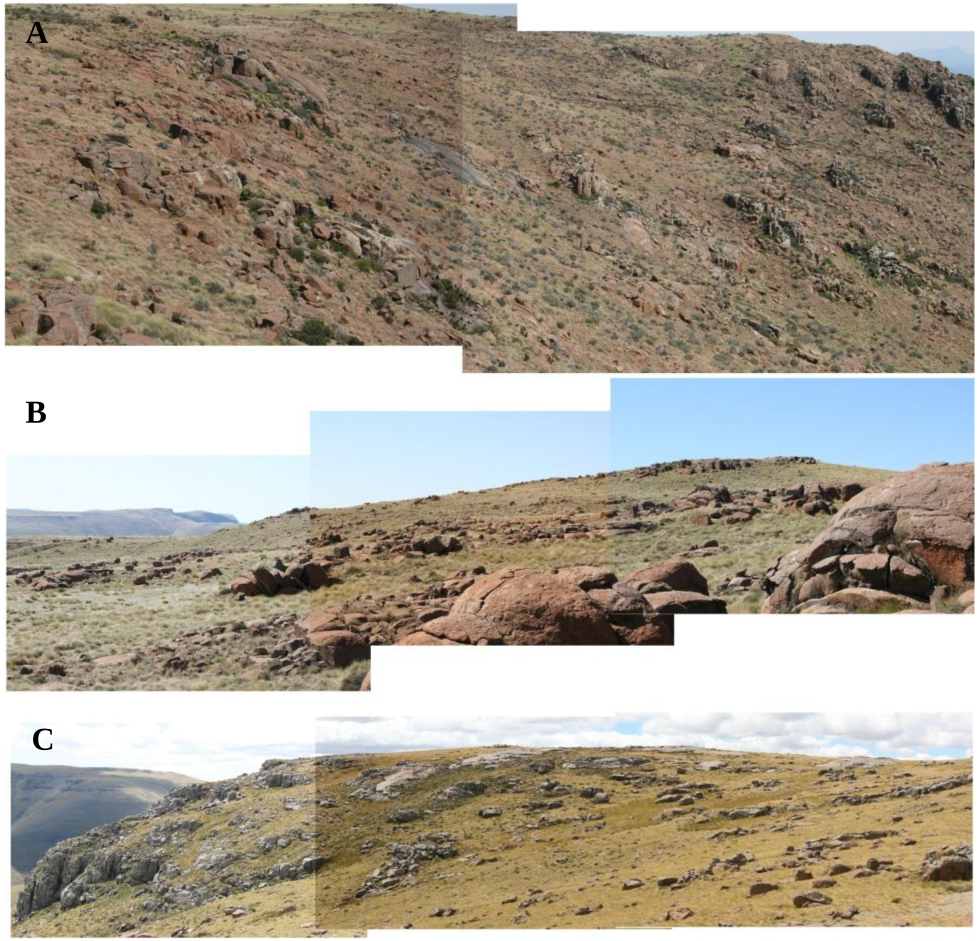

Figure 2.4: Photographs spliced together, giving panoramic views of boulder fields 1 (A), 2 (B) and 3 (C) (refer to Figure 2.3).

Field trips to Asante Sana were conducted specifically for observation purposes between May 2010 and November 2011, in all seasons. Three observation sites were selected (Figure 2.3 and 2.4). These were areas of good habitat (gently sloping boulder fields, dominated by grassy vegetation), and contained at least one bird pair. Observations would be conducted from morning until late afternoon (roughly 08h00-16h00). During this time, clap traps would also be set up in order to catch individual birds (Appendix 1). Data taken from these individuals included age, sex, wing length, mass, and moult and brood patch status. A single tail feather (and any other incidental body feathers that fell out during handling) was kept for DNA analyses (see Chapter 3). Each bird was colour ringed with unique individual colour combinations to enable future identification.

Birds were observed using binoculars from a single position during the course of the day, so as to keep disturbance to a minimum. The bird’s activities were noted and photographed, including foraging details, perch selection, interactions with other birds, preening and territory defence. Unfortunately, the observational data were not recorded in a form which would enable a time budget or quantitative comparison to be constructed. An effort has been made, however, to back observations with photographic evidence.

Dietary Sample Collection and Analyses

Whenever a bird was seen to defecate (just after being caught in a trap, while in the handling bag, in the hand, or while moving, foraging or displaying), the faecal sample was collected. This method of sample collection (also used by Bryant 1973; Davies 1976, 1977a and b; Oatley *et al*. 1989; Tigar & Osborne 2000) was chosen over gut flushing (Moody 1970; Major 1990), forced regurgitation (Poulin & Lefebvre 1997; Collins *et al*. 2010) and whole-stomach collecting (Franzblau & Collins 1980; Sherry 1984; Kopij 2003; 2005a and b) due to the low capture rate of these birds, and ethical considerations. Samples were wrapped in filter paper, sealed in a paper envelope and marked. These samples were allowed to dry, and then analysed under an Olympus SZX16 stereo microscope, with an Olympus DP72 camera attached to it. Insect fragments found in the faecal samples were identified using Picker *et al*. (2004).

Results

Morphometric and Moult Data

Morphometric data collected from caught samples showed that there is no significant difference between males and females in terms of mass ($P > 0.05$; $t = 0.006$) or wing length ($P > 0.05$; $t = 0.0009$) (Table 2.1).

Birds caught between February and May all showed signs of moulting (wing, head, body and tail). This was particularly notable in March and early April, when the wing feathers were almost always either recently dropped, or in early-mid growth stages (Table 2.1). During this time, birds even showed visible signs of moulting (Figure 2.5).

Figure 2.5: A male rock-jumper, seen in the Winterberg in February 2012, showing visible signs of body moult.

Table 2.1: The capture date, ring number, morphometric data, wing moult patterns and location of each of the 23 sampled birds. For brood patch status, 0: Absent, 1: Present, 2: Growing over. For wing moult, P1 refers to the first primary, P2 to the second etc. S1 refers to the first secondary, S2 to the second etc. The degree of feather growth ranges from 0 (not present) to 5 (fully grown).

Date of Capture	Ring number	Sex	Wing [mm]	Mass [g]	Brood patch	Wing moult																				Area	Altitude [m]
02 May 2011	CC75783	F				P1	5	P2	5	P3	5	P4	5	P5	5	P6	5	P7	5	P8	5	P9	5	P10	5	Asante Sana	1985
						S1	3	S2	3	S3	4	S4	5	S5	5	S6	5	S7	5	S8	5	S9	5				
27 Jun 2011	CC75784	F	81	49	0	P1	3	P2	5	P3	5	P4	5	P5	5	P6	5	P7	5	P8	5	P9	4	P10	4	Naude’s Nek	2554
						S1	3	S2	4	S3	4	S4	5	S5	5	S6	5	S7	5	S8	5	S9	5				
09 Sept 2011	CC75785	M	89	58	1	P1	5	P2	5	P3	5	P4	5	P5	5	P6	5	P7	5	P8	5	P9	4	P10	3	Asante Sana	1755
						S1	4	S2	5	S3	5	S4	5	S5	5	S6	5	S7	5	S8	5	S9	5				
11 Sept 2011	CC75786	F	86	49	1	P1	5	P2	5	P3	5	P4	5	P5	5	P6	5	P7	5	P8	5	P9	5	P10	4	Asante Sana	1773
						S1	4	S2	5	S3	5	S4	5	S5	5	S6	5	S7	5	S8	5	S9	5				
04 Oct 2011	CC75787	M	93	54	1	P1	5	P2	5	P3	5	P4	5	P5	5	P6	5	P7	5	P8	5	P9	5	P10	4	Katberg Pass	1720
						S1	4	S2	4	S3	5	S4	5	S5	5	S6	5	S7	5	S8	5	S9	5				
09 Oct 2011	CC75788	M	93	57	1	P1	5	P2	5	P3	5	P4	5	P5	5	P6	5	P7	5	P8	5	P9	5	P10	5	Asante Sana	2023
						S1	3	S2	3	S3	3	S4	5	S5	5	S6	5	S7	5	S8	5	S9	5				
04 Nov 2011	CC75789	F	83	48	1	P1	5	P2	5	P3	5	P4	5	P5	5	P6	5	P7	5	P8	5	P9	5	P10	5	Naude’s Nek	2462
						S1	3	S2	4	S3	5	S4	5	S5	5	S6	5	S7	5	S8	5	S9	5				
08 Nov 2011	CC75790	F	85	50	1	P1	5	P2	5	P3	5	P4	5	P5	5	P6	5	P7	5	P8	5	P9	5	P10	5	Naude’s Nek	2434
						S1	5	S2	5	S3	5	S4	5	S5	5	S6	5	S7	5	S8	5	S9	5				
08 Nov 2011	CC75791	M	84	51	1	P1	5	P2	5	P3	5	P4	5	P5	5	P6	5	P7	5	P8	5	P9	5	P10	5	Naude’s Nek	2434
						S1	5	S2	5	S3	5	S4	5	S5	5	S6	5	S7	5	S8	5	S9	5				
15 Nov 2011	CC75792	F	86	Escaped	1	P1	5	P2	5	P3	5	P4	5	P5	5	P6	5	P7	5	P8	5	P9	5	P10	5	Asante Sana	2003
						S1	5	S2	5	S3	5	S4	5	S5	5	S6	5	S7	5	S8	5	S9	5				
03 Dec 2011	CC75793	F	85	53	1	P1	5	P2	5	P3	5	P4	5	P5	5	P6	5	P7	5	P8	5	P9	5	P10	5	Asante Sana	1770
						S1	5	S2	5	S3	5	S4	5	S5	5	S6	5	S7	5	S8	5	S9	5				
04 Dec 2011	CC75794	M	95	59	1	P1	5	P2	5	P3	5	P4	5	P5	5	P6	5	P7	5	P8	5	P9	5	P10	5	Asante Sana	1962
						S1	5	S2	5	S3	5	S4	5	S5	5	S6	5	S7	5	S8	5	S9	5				
23 Jan 2012	CC75795	M	97	55	1	P1	5	P2	5	P3	5	P4	5	P5	5	P6	5	P7	5	P8	5	P9	5	P10	5	Asante Sana	1958
						S1	5	S2	5	S3	5	S4	5	S5	5	S6	5	S7	5	S8	5	S9	5				
23 Jan 2012	CC75796	F	88	47	1	P1	5	P2	5	P3	5	P4	5	P5	5	P6	5	P7	5	P8	5	P9	5	P10	5	Asante Sana	1958
						S1	5	S2	5	S3	5	S4	5	S5	5	S6	5	S7	5	S8	5	S9	5				

Date of Capture	Ring number	Sex	Wing [mm]	Mass [g]	Brood patch	Wing moult																				Area	Altitude [m]
23 Jan 2012	CC75797	F	81	51	1	P1	5	P2	5	P3	5	P4	5	P5	5	P6	5	P7	5	P8	5	P9	5	P10	5	Asante Sana	1958
						S1	5	S2	5	S3	5	S4	5	S5	5	S6	5	S7	5	S8	5	S9	5				
29 Jan 2012	CC75801	F	86	47	2	P1	5	P2	5	P3	5	P4	5	P5	5	P6	5	P7	5	P8	5	P9	5	P10	5	Naude’s Nek	2365
						S1	5	S2	5	S3	5	S4	5	S5	5	S6	5	S7	5	S8	5	S9	5				
23 Feb 2012	CC75798	M	87	49	1	P1	5	P2	5	P3	5	P4	5	P5	5	P6	5	P7	5	P8	5	P9	5	P10	5	Winterberg	1838
						S1	5	S2	5	S3	5	S4	5	S5	5	S6	4	S7	4	S8	4	S9	4				
20 Mar 2012	CC75799	F	82	56	2	P1	5	P2	5	P3	5	P4	5	P5	5	P6	5	P7	5	P8	5	P9	5	P10	5	Klein Winterberg	2076
						S1	1	S2	2	S3	2	S4	3	S5	3	S6	4	S7	5	S8	5	S9	5				
20 Mar 2012	CC75800	F	91	60	2	P1	1	P2	5	P3	5	P4	5	P5	5	P6	5	P7	5	P8	5	P9	5	P10	5	Klein Winterberg	2076
						S1	1	S2	1	S3	4	S4	4	S5	5	S6	5	S7	5	S8	5	S9	5				
21 Mar 2012	CC53769	M	87	54	2	P1	5	P2	5	P3	5	P4	5	P5	5	P6	5	P7	5	P8	4	P9	4	P10	4	Klein Winterberg	2071
						S1	0	S2	0	S3	0	S4	0	S5	0	S6	0	S7	0	S8	3	S9	3				
18 Apr 2012	CC53770	F	82	49	2	P1	5	P2	5	P3	5	P4	5	P5	5	P6	5	P7	5	P8	5	P9	5	P10	5	Stormberg	1973
						S1	5	S2	5	S3	5	S4	4	S5	0	S6	0	S7	5	S8	5	S9					
19 Apr 2012	CC53771	M	92	57	2	P1	5	P2	5	P3	5	P4	5	P5	5	P6	5	P7	5	P8	5	P9	5	P10	5	Stormberg	1964
						S1	5	S2	5	S3	5	S4	5	S5	5	S6	4	S7	4	S8	3	S9	0				
19 Apr 2012	CC53772	M	88	59	2	P1	5	P2	5	P3	5	P4	5	P5	5	P6	5	P7	5	P8	5	P9	5	P10	5	Stormberg	1964
						S1	5	S2	5	S3	5	S4	5	S5	5	S6	5	S7	0	S8	0	S9	0				

Colour Ringing

The birds were typically found in pairs or small family groups. The largest of these family groups was in Boulder Field 2 (Figure 2.3C), and contained at least six birds (six were colour ringed in this area). No colour ringed birds were observed outside of the boulder field where they had been initially ringed.

Territories: defence, display and song

By playing back a recorded rock-jumper call, it was usually possible to induce a response in nearby individuals. Typically, they would fly in to the vicinity and then call and display in response from a prominent rock. Occasionally, they would ignore the call recording altogether, and continue foraging: a response which was particularly noticeable outside of the breeding season (Appendix 1).

The birds were typically found in pairs or small family groups (Figure 2.8). These would establish and maintain territories within their boulder field habitats. The size of a territory was estimated by observing conflicts between neighbouring parties, and found to be no more than 300 m across its widest points. These conflicts usually took the form of a short (*c.* 1 minute) vocal and display bout between individuals, occasionally with physical contact between them.

Figure 2.6: A rock-jumper pair (left and middle) sees off an invading female (right). Note the fanned, cocked tails of the two females.

Another particular exchange that occurred was between individuals on the same territory (a pair), where each bird would be foraging alone, and suddenly spot the other. A short exchange would then occur before recognition was re-established. Birds remained in their associated territories year round, but seemed to become especially vigilant in territory defence immediately prior to, and during, the breeding period (August to February: Hockey *et al*. 2005). Preening was also an important activity, particularly in males. Birds would spend long periods of time (approximately one hour) sitting on a large boulder, attending to their feathers.

Foraging

Observed birds had a very distinct foraging style: they moved in a generally upslope direction using short running bursts (up to 2 m in length), hopping (between one and four hops, up to 1 m total distance), or a combination of the two. A typical foraging bout would consist of a series of displacements (either hopping or running), quickly interspersed with feeding. Prey items were gleaned from grass tussocks, bare ground, and occasionally rock or boulder surfaces. Prey was only carried for any distance when adults were feeding chicks (Figure 2.7A). During normal foraging, prey was either swallowed whole or – if it was too large – bashed on the ground or on a rock in order to break it apart. Birds frequently wiped their beaks after handling larger prey (Figure 2.7B).

Birds showed a strong preference for foraging in grass that was either very short (*c*. 5 cm) or had only sparsely spaced tussocks, interspersed with short grass, bare ground and rocks (Figures 2.8 and 2.9 respectively).

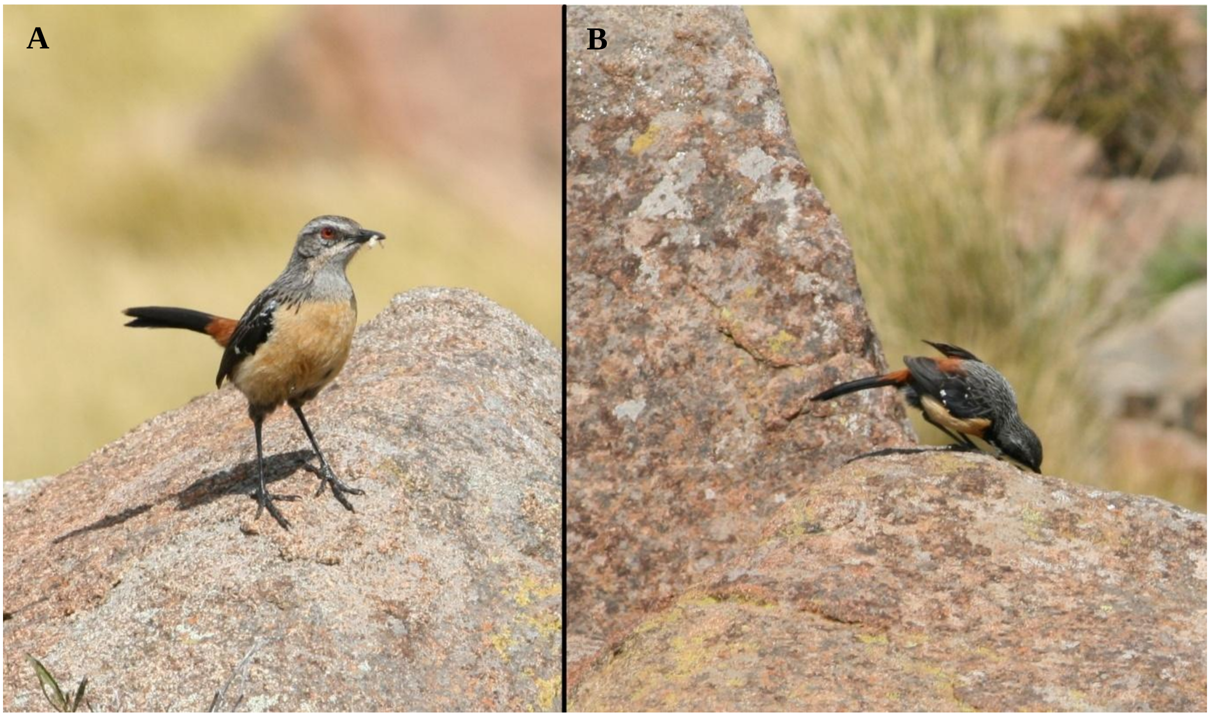

Figure 2.7: A: A female rock-jumper carrying an insect larva. B: A male rock-jumper wiping its beak.

Figure 2.8: Two males and a female (middle) foraging in a grazed field in the Naude's Nek area.

Figure 2.9: A single female foraging in short grass interspersed with larger grass tussocks in the Naude’s Nek area.

Perch Selection

Although the birds foraged along the ground, they were only ever seen perching on rocks. Rocks 0-1 m high were normally used as vantage points for brief scans during foraging, where a bird would alight on the top of a rock, do a short scan (possibly give a brief call), and drop down the other side to continue foraging. Birds would also use perches as vantage points to locate prey items in the grass (Figure 2.10).

Figure 2.10: A female rock-jumper uses a rock as a vantage point to spot prey items hidden in the grass.

Higher rocks (2-5 m) were normally used for longer scans (approximately 5+ minutes), preening, and as stages for calling and displaying. Birds found at sites at higher altitudes (over 2000 m, in the Stormberg and southern Drakensberg) also used lower (< 1m) perches than birds found in lower altitude sites (below 2000 m, in the Winterberg and Sneeuberg). Sites at higher altitude also had shorter grass cover (Figures 2.6, 2.8 and 2.9) due to grazing of livestock in these areas.

Flying

After birds completed a single foraging bout, they would either perch on a rock for a short time, but more often fly away from the foraging area to do this, or start another foraging bout a short distance away. Although rock-jumpers were seldom seen to fly any considerable distance (the longest observed was approximately 30 m), they do glide well. They never fed on the wing (despite flying insects being present), but I did on one occasion see them calling while flying.

Behavioural responses to temperature conditions

Environmental temperature appeared to play an important role in bird activities. During cold (particularly windy) weather during field excursions to the Naude’s Nek area (June-July 2011; Figure 2.11), bird pairs were seen to huddle together, making use of rock crevices and other micro-climates to avoid the wind. Especially hot weather also induced a panting response in birds (Figure 1.3B).

Figure 2.11: A female spotted in the winter snow near the Naude's Nek pass. A few days earlier, birds had been observed in the same boulder field when temperatures had been approximately -17°C (Dave Walker, pers. comm. 2011).

Habitat selection

Birds found at altitudes close to their lower altitude threshold (notably those found in the Sneeuberg and Winterberg) were observed to be more habitat specific than those found at higher altitudes (in the Stormberg and southern Drakensberg). Birds at lower altitudes (below 2000 m) were only seen in boulder fields, and usually boulder fields dominated by grassy – rather than bushy – vegetation (for rock-jumpers, this could be thought of as “good” habitat: Figure 2.12 C and D). Birds at higher altitudes (above 2000 m) were often seen foraging up to 100 m or more away from the nearest rock outcrops, which in themselves were either very small “boulder fields” (a few small rocks scattered around on a hill slope), or simple rock outcrops (this would be “bad” habitat), often dominated by scrub or bushy vegetation (Figure 2.12A and B).

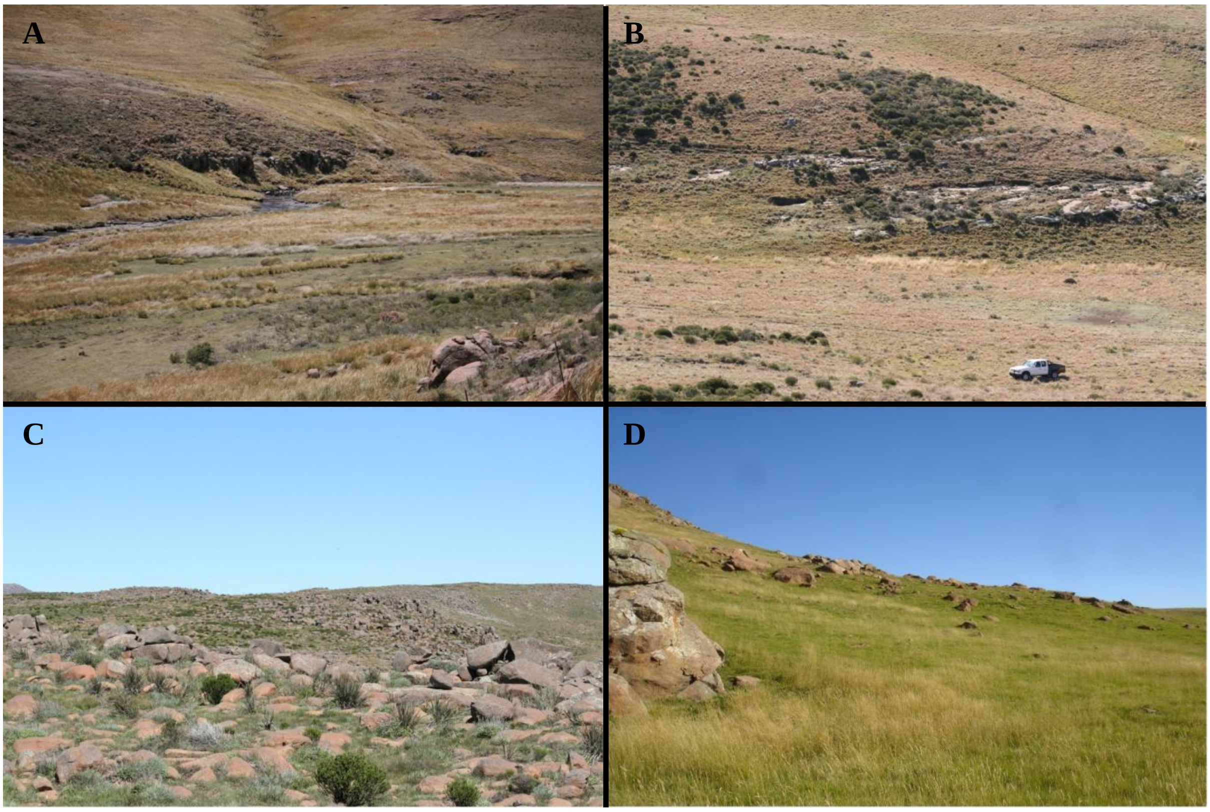

Figure 2.12: Examples of "bad" (A and B) and "good" (C and D) habitat. Rock-jumpers were found in all four areas. A: A piece of grazing land next to the Bell River in the Naude's Nek area, with some sparse rocks on the river's far side. B: A small, grazed valley on the Leeufontein Farm in the Stormberg, with a small rock outcrop on the far slope. C: A very extensive boulder field on the Klein Winterberg, with few bushes, short grass and large rocks. D: A boulder field at Mountain Zebra National Park, with large rocks and pristine grass.

Interactions with other bird species

A number of other species were seen in the same locality as rock-jumper pairs or groups. Some of these are notable, due to the fact that they too are known to eat insects and thus represent potential competitors for food. These are:

- Sentinel rockthrush (*Monticola explorator*)
- Ground woodpecker (*Geocolaptes olivaceus*)
- Red-winged starling (*Onychognathus morio*)

- Ant-eating chat (*Myrmecocichla formicivora*)
- Sickle-winged chat (*Cercomela sinuata*)
- Long-billed lark (*Mirafra curvirostris*)
- Fiscal shrike (*Lanius collaris*)

Interactions in the form of vocal outbursts and short pursuits between rock-jumpers and other species were rare. However, Sentinel rockthrushes (*M. explorator*) were a common cause for interaction, and on one occasion, a rock-jumper was even observed stealing a prey item from a Sentinel rockthrush.

Diet

A total of fifteen faecal samples were collected during the study (eight from Asante Sana, three from the Klein Winterberg, one from Leeufontein and three from Naude's Nek). These samples all showed that the birds were indeed exclusively insectivorous, and ate predominantly ants or beetles (Figure 2.13). No evidence of any plant material, such as seeds or any plant fragments was found. There is, however, a possibility that rock-jumpers are eating earthworms in addition to insects. These would, in all likelihood, be completely destroyed during digestion, and therefore not seen in the faecal samples. Samples containing predominantly ants were found in the Winterberg, Stormberg and southern Drakensberg, while those containing mostly beetles were taken from the Sneeuberg.

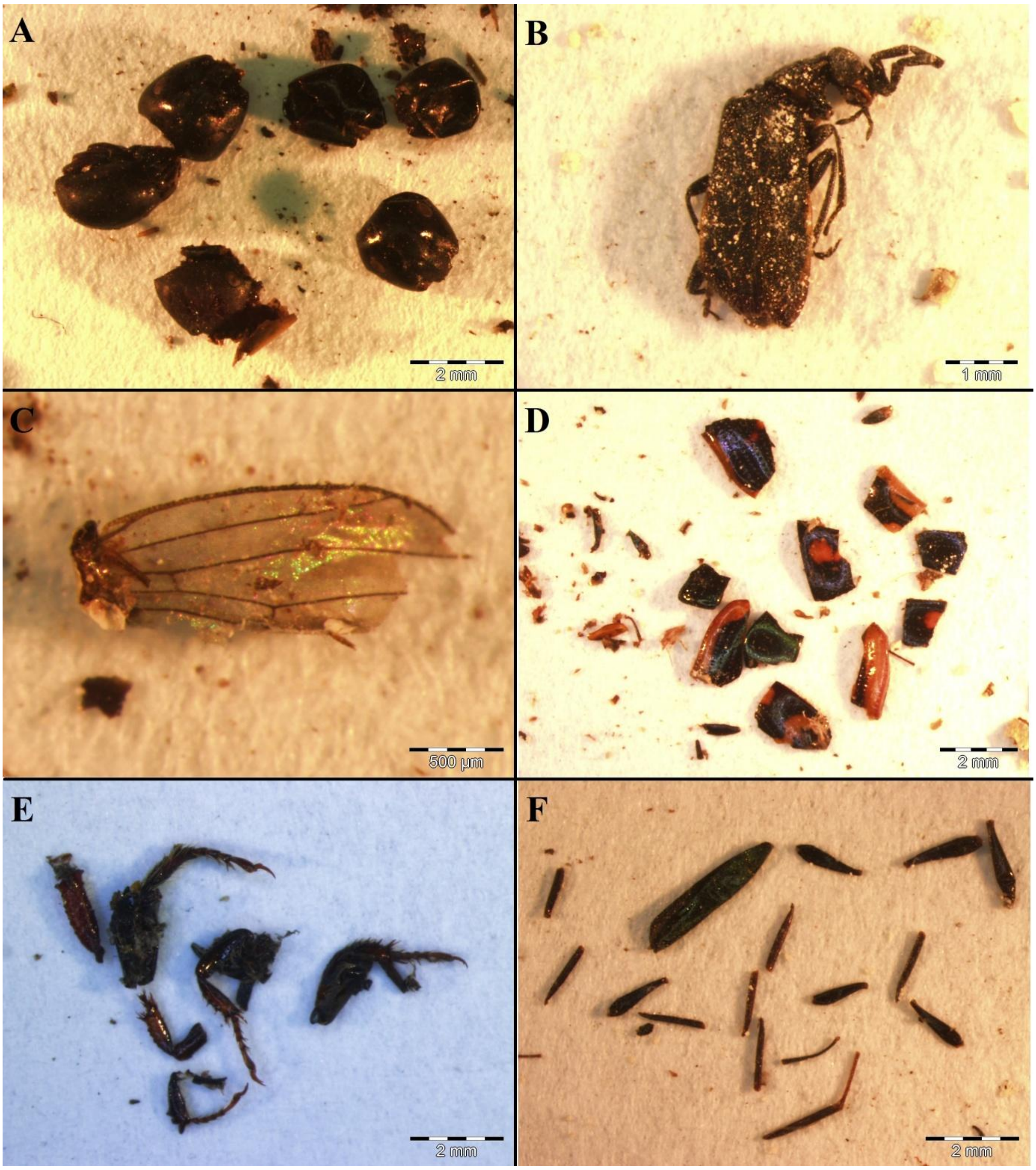

Figure 2.13: Examples of items found in faecal samples. A: Ant heads. B: The nearly complete body of a beetle. C: A wing fragment. D: Elytra and other chitinous fragments. E and F: Leg fragments.

Discussion

Social organisation and behaviour

Rock-jumpers are social birds, and were associated in male-and-female pairs up to groups of twelve individuals of both sexes. Their territories play an important role in breeding and foraging and are maintained year-round, by singing and displaying from prominent rocks. The concept of birds maintaining territories and assisting in the breeding efforts of close relatives has been the subject of much research, and there are several well-studied South African examples. However, rock-jumpers may represent facultative rather than obligate cooperative breeders (Du Plessis *et al*. 1995).

Covas *et al*. (2006) analysed the cooperative nature of the Sociable Weaver (*Philetairus socius*), a Namibian and South African Endemic which is known for the large thatch-like communal structures it builds in the trees of savannah environments. The study showed how non-breeding helpers are more related to the young in a helped nest than other nestlings in the colony. The sympatric Red-billed and Alpine Choughs (*Pyrrhocorax pyrrhocrax* and *P. graculus* respectively) live in pairs, with sexes cooperating to raise young. A study by Laiolo & Rolando (2001) in the Italian Alps showed how these two species can co-exist at high elevations due to differences in their nest site selection, laying dates and feeding ecology. Delestrade (1999), also studying the Alpine Chough (*P. graculus*), varied the amount of food and food patches available to birds. She found that the long term advantages of flocking related to social bonds (such as maintenance of pair bonds) may compensate for short term costs (such as reduction in foraging efficiency). Salewski *et al*. (2002) studied two birds: the Pied Flycatcher (*Ficedula hypoleuca*) and the Willow Warbler (*Phylloscopus trochilus*), both palearctic migrants which fly to West Africa for the winter. They found that the Pied Flycatcher does not move from its winter territory, as it is a generalist feeder. The Willow

Warbler does not stay long in one area, due to it being a specialist and dependent on patchily distributed food.

These examples show the advantages of flocking and cooperative behaviour for breeding and foraging. In areas with rapidly changing climate conditions – such as the alpine boulder fields that rock-jumpers live in – this can be especially important. Savannah Sparrows in alpine and sub-alpine environments in British Columbia have adopted a low fecundity, high survival life history strategy over their conspecifics living at lower elevations (Martin *et al*. 2009). The American Pipit is a summer-nesting bird, and an opportunistic study by Hendricks & Norment (1992) showed how an un-predictable mid-summer snowstorm can have a devastating effect on nestling survival.

Diet and foraging

The dietary analysis supports the foraging observations that rock-jumpers only eat terrestrial insects. The bill morphology is also adapted for this purpose: Irwin (1985) calls it "remarkably thrush-like" (p. 99). However, the information collected for this study is skewed toward hard-bodied insects – soft bodied insects would obviously have a poorer chance of passing intact through the digestive tract, and would be present in much lower abundance in the faecal samples (if at all) (Custer & Pitelka 1975; Ford *et al*. 1982; Major 1990; Kopij 2005a). However, Davies (1976) did find that dietary samples of pied wagtails (*Motacilla alba*) taken by emetic methods compared well to faecal samples, and gave good representation of initial food intake. However, rock-jumpers have been reported carrying grasshoppers and caterpillars to nest sites in order to feed chicks (Figure 2.6A) (Tait 1948; Little & Bainbridge 1992).

The apparent variation in diet between the Sneeuberg and the Stormberg-Drakensberg mountain blocks is possibly a result of the difference in vegetation biomes present in each. The Sneeuberg falls roughly into the Karoo biome, with the Grassland biome dominating to the east, and each of these has distinctive associated insect assemblages (Picker *et al.* 2004). This suggests that the birds are more generalist foragers, feeding on what is available to them rather than specialising on particular insect groups.

The foraging tactics of rock-jumpers are clearly those of active search predators, rather than sit-and-wait ambush foragers, such as the Buffstreaked chat *Oenanthe bifasciata* (Tye 1987) and the Fiscal shrike *Lanius collaris* (Devereux 1998; Soobramoney *et al*. 2004). It is also possible that they have adaptive plumage for this purpose: insectivorous birds with white tipped wing and tail feathers have been shown to use these features to startle and flush potential prey, which is then pursued and captured (Remsen & Robinson 1990; Mumme 2002). If this is indeed the case, this colouration would serve two purposes, as it is also clearly used for display and intraspecific communication (Figure 2.5).

Habitat requirements – The need for boulder fields

The habitat requirements of rock-jumpers seem to become more stringent as the lower limit of their altitudinal restriction is reached. Exactly why this species is altitudinally restricted in this way is not yet known. Its close relative, the Cape rock-jumper (*Chaetops frenatus*) lives in similar boulder fields, but at much lower altitudes (Holmes *et al*. 2002; Hockey *et al*. 2005) and even down to sea level (Craig 1991; M. Ford, pers. comm. 2011). This study has suggested that there is a more stringent need for boulder fields for birds living at lower altitudes (i.e. close to their 1500 m lower threshold limit) than those living at higher altitudes (*c*. 2000 m and higher). I would suggest that there are two possible answers for this anomaly: breeding and nesting requirements, and foraging requirements.

In terms of breeding and nesting, rock-jumpers do use the boulders for territory maintenance and display, which is likely to play a role in mating success (Collins 1969). Secondly, the nests of rock-jumpers are typically found up against large rocks and boulders (Tait 1948; Barnes 1969; Du Plessis 1990), probably for protective purposes, both from local climate and predators.

The use of boulders for foraging is probably secondary, but nonetheless important. The bird's insect food is not restricted to these areas (Picker *et al*. 2004), but a boulder-dominated landscape may create better foraging opportunities for the birds, particularly as rocks can be used as vantage points to spot prey (Figure 2.9). Studies by Soobramoney *et al*. (2004) and Devereux (1998) on the Fiscal shrike (*Lanius collaris*), and by Tye (1987) on the Buffstreaked chat (*Oenanthe bifasciata*) have shown that these birds make use of vantage points for prey spotting. Moreover, these studies show that as surrounding vegetation height increases, these species make use of taller vantage points, and increase their frequency of vantage point use. It is possible that this may also explain the stringent requirements rock-jumpers have for particular habitat regimes in the Sneeuberg – Asante Sana and Mountain Zebra National Park do not have high numbers of grazing animals at high altitude. Indeed, only Klipspringer (*Oreotragus oreotragus*) has been spotted at high altitude in both areas. Sites in the Winterberg, Stormberg and southern Drakensberg were all grazed farmland, and had short grass – allowing the rock-jumpers better foraging opportunities at ground level, and thus less need for boulders as vantage points.

Potential competition with other species

The rock-jumpers in the Eastern Cape clearly co-exist with a number of other bird species. Of those recorded, the Ground woodpecker (*G. olivaceus*) warrants further discussion as it lives in small family groups and occupies very similar habitats to the Drakensberg rock-jumper, and is therefore a potential competitor (Hockey *et al*. 2005). Similarly, the Sentinel rockthrush (*M. explorator*) and the Drakensberg siskin (*Pseudochloroptila symonsi*) occupy similar habitats and partly overlap with the rock-jumper's diet (Hockey *et al*. 2005), although the siskin was never seen during this study, as it is largely restricted to the main Drakensberg. The British evolutionary biologist and ornithologist, David Lack, noted that "two species of animals can coexist in the same area only if they differ in ecology" (1971, p. 1), a concept he famously explored with Darwin's finches. Although somewhat out-dated, his concepts can be applied here. The rock-jumper is insectivorous, and makes use of boulder fields for breeding (Tait 1948; Barnes 1969; Du Plessis 1990; Tarboton 2001) and – possibly – feeding requirements (see above). The Ground woodpecker is much more restricted in its diet, eating almost exclusively ants (Oatley *et al*. 1989), but has a much larger range size and broader habitat requirements (Hockey *et al*. 2005). Conversely, the Sentinel rockthrush has similar habitat requirements (albeit a larger range), but broader dietary needs – it eats insects, but fruit and seeds as well (Clement & Hathway 2000; Hockey *et al*. 2005). The Drakensberg siskin uses rock ledges and cliffs for nesting and breeding, but lives for the rest of the year in alpine grasslands and montane scrub, also with broader feeding habits, eating insects, seeds, and small buds (Hockey *et al*. 2005). The siskin therefore has different nesting requirements to the rock-jumper and the rockthrush, which build their nests in close proximity to boulders (Tarboton 2001). These in turn differ from the woodpecker, which burrows into the sides of river banks and gullies in order to construct its nests (Hockey *et al*. 2005). A further consideration is the role that altitudinal migration plays: the woodpecker is a year-round resident, while the rock-jumper, siskin and the rockthrush that live at higher altitudes (a figure which varies between species) are all reported to move to lower elevations in winter (Clement & Hathway 2000; Hockey *et al*. 2005), although as has been pointed out, the reliability of these claims in the rock-jumper's case should possibly be questioned.

CHAPTER 3

GENETIC VARIATION WITHIN AND BETWEEN POPULATIONS

Introduction

The Drakensberg rock-jumper in the Eastern Cape

The genus *Chaetops*, represented by the two species *C. frenatus* and *C. aurantius*, forms one of the stronger faunal links between the Drakensberg Alpine Centre (DAC) and the Cape Floristic Region (CFR) (Clark *et al*. 2009; 2011c). The mountain ranges that link these two botanical centres lie in the Eastern Cape, and are formed by an interrupted section of the Great Escarpment, divided into (from west to east) the Sneeuberg, Winterberg, Stormberg and the southern Drakensberg (Clark 2011b and c). The Great Fish and Kei Rivers form potential biogeographic divides between the Sneeuberg and Winterberg, and Winterberg and Stormberg respectively (Figure 1.2). The incision of these rivers through the Escarpment in this area could potentially create biogeographic divides for these plants and animals, but recent studies have shown that – at least from a floristic perspective – this may not be the case (Clark *et al*. 2009; 2011a). These mountain ranges play host to a number of high-altitude, or alpine dwelling fauna and flora, and exhibit significantly high levels of endemism (Little 1992; Little *et al*. 1993; Johnson & Maclean 1994; Hoare & Bredenkamp 1999; 2001; Clark *et al*. 2009; 2011a, b and c; Fearon 2011; Kok 2011; Kok *et al*. 2012).

The Drakensberg rock-jumper (*C. aurantius*) is found along the Great Escarpment from northern Lesotho in the Drakensberg highlands to the Koudeveldberge of the Sneeuberg (Hockey *et al*. 2005; Clark *et al*. 2012). This species is altitudinally restricted and has stringent habitat requirements (Coghlan 1969; Collins 1969; Hockey *et al*. 2005), and the birds maintain year-round territories and have not been directly observed to fly long distances (Chapter 2). They are reported to undertake seasonal altitudinal migrations in the high Drakensberg (Johnson & Maclean 1994; Hockey *et al*. 2005), and this could suggest that they are theoretically capable of moving between areas of isolated favourable habitat, or even between mountain ranges.

Study Aims

This part of the study explores the genetic diversity of the rock-jumper using mtDNA sequences. The part of the southern Escarpment that lies within the Eastern Cape is a non-continuous mountain range, and as such can cause potential genetic isolation from one mountain block to the next. This bird provides an ideal avifaunal opportunity to explore how these mountain ranges act as corridors for high-altitude and Drakensberg endemics to move and expand their ranges, and how the southern Escarpment endemics may become genetically isolated in their respective mountain blocks.

There are three main reasons for undertaking a genetic based study on the Drakensberg rock-jumper. Firstly, it provides the beginnings of the first avifaunal study looking at the potential links between the DAC and CFR (the CFR being home to the Cape rock-jumper *C. aurantius*: Hockey *et al.* 2005), and an understanding of the role that mountain corridors play in this regard for high-altitude and alpine species and their gene flow. Secondly, a good understanding of how a species moves around its distribution range is vital for effective conservation, and genetic analyses can assist in providing this knowledge (Haig *et al*. 2011; Krishnamurthy & Francis 2012). Finally, no such work has been done on it to date.

Why use genetic analyses?

Single-species genetic studies (e.g. Zink *et al*. 2000; Barrowclough *et al.* 2004; 2011; Alexander & Burns 2006; Spellman *et al*. 2007; Spellman & Klicka 2007; Fuchs *et al*. 2011; Miller *et al*. 2011) remain of high interest to systematists and evolutionary biologists, but in order to gain a good understanding of the evolution of species distribution and the mechanisms that have shaped them it is necessary to compare a number of co-distributing species (Avise 1998; Haig *et al*. 2011; Klicka *et al*. 2011).

In the last decade, single-species genetic studies have concentrated on re-assessing sub-species differentiation (which is traditionally based on morphological, plumage and vocal differences), the timing at which these divergences occur, and the explanation of a mechanism for the divergence (e.g. geographic separation at the end of the last glacial maximum). These are particularly important in the passerine group, as these birds "show a remarkable anatomical uniformity, except for structures adapted for feeding and locomotion" (Zuccon *et al*. 2006, p. 333). Such single-species studies include the Blue grouse *Dendragapus obscurus* (Barrowclough *et al*. 2004); the White-headed woodpecker *Picoides albolarvatus* (Alexander & Burns 2006); the White-breasted nuthatch *Sitta carolinensis* (Spellman & Klicka 2007); the Mountain chickadee *Poecile gambeli* (Spellman *et al*. 2007); the Barred owl *Strix varia* (Barrowclough *et al.* 2011); the Fiscal shrike *Lanius collaris* (Fuchs *et al*. 2011); the Hairy woodpecker *Picoides villosus* (Klicka *et al.* 2011); and the Ostrich *Struthio camelus* (Miller *et al*. 2011). Of these studies, Barrowclough *et al*. (2004; 2011), Alexander & Burns (2006) and Miller *et al.* (2011), as well as Ellegren (1991), Tarberlet & Bouvet (1991), Zink *et al*. (2000), Bello *et al*. (2001), Smith *et al*. (2003), Harvey *et al*. (2006) and Fuchs *et al.* (2006) used feathers as sources of DNA. Recently, the use of feathers as a DNA source has come under ethical scrutiny: McDonald & Griffith (2011) argue that plucked feathers yield relatively low quantities of poor quality DNA, as well as affecting the individual’s status, attractiveness (and therefore fitness), and physiological and metabolic costs (and by inference, survival). Harvey *et al*. (2006) tested blood versus feather samples as DNA sources for molecular sexing, and found that feathers were equally as reliable. Given the number of studies that have successfully extracted DNA from feathers (see above), I feel that McDonald & Griffith’s (2011 p. 198) statement that “feathers yield low levels of relatively poor quality DNA” is perhaps unfounded. Furthermore, feather sampling can be done very quickly and easily (meaning less time in the hand, and less stress on the bird), and little is required in the way of training of field techniques or specialised equipment (needles, syringes etc.). Moreover, a few body feathers usually fall out while a bird is being handled and processed, and these can easily be collected and stored.

Mitochondrial DNA is one of the most frequently used markers in phylogenetic analyses, due to its maternal inheritance, haploidy and rapid rate of evolution (Sorenson *et al*. 1999). Avian mtDNA comprises sixteen genes, each of which shows considerable variation in rates of change (Johnson & Sorenson 1998; Sorenson *et al*. 1999). Of these genes, NADH dehydrogenase subunit 2 (ND2) shows high levels of amino acid substitution – indeed the only genes that show higher levels are ATPase 8 and ND6, both of which are relatively short and generally more difficult to amplify and sequence (Johnson & Sorenson 1998; Dimcheff *et al*. 2002). ND2 has also proven successful in other Passeriform studies (Drovestski *et al*. 2004; Zink *et al*. 2006; Zuccon *et al*. 2006; Klicka *et al*. 2011).

Materials and Methods

Sample Collection

Sampling took place between May 2010 and April 2011 in field sites across the rock-jumper's distribution range within the Eastern Cape (Figure 3.1). 25 birds were caught using clap-traps (Appendix 1), ringed, and a single tail feather (as well as any other feathers that fell out during handling and processing) was taken as a DNA sample[2]. These were placed in marked envelopes and stored in a cool, dry area until processing.

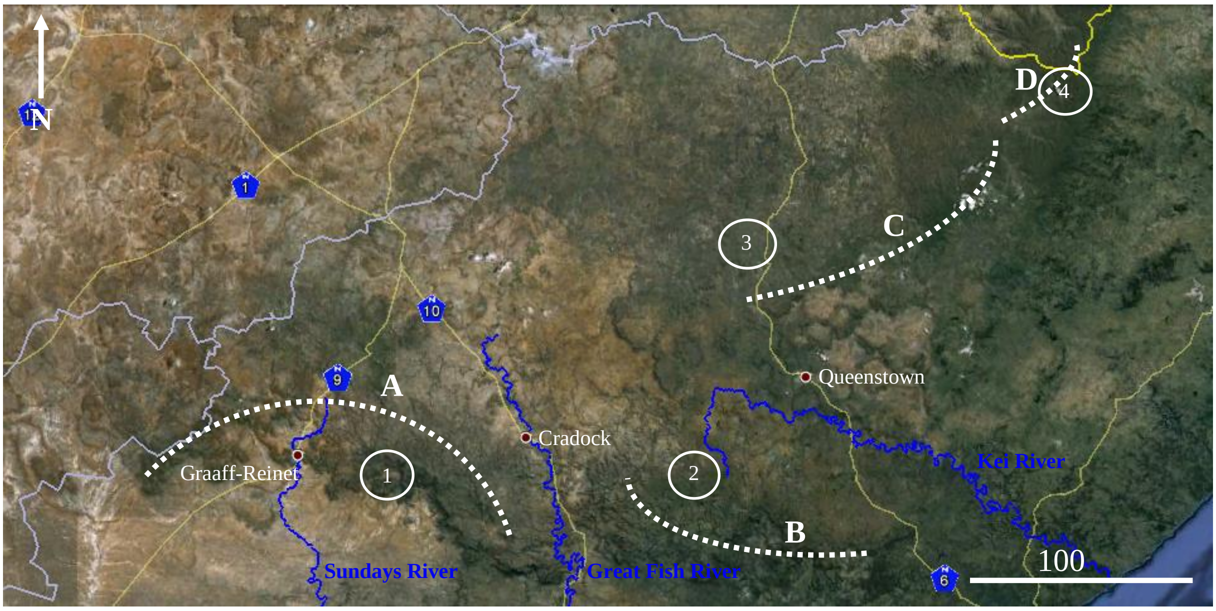

Figure 3.1: The Great Escarpment within the Eastern Cape, indicating the main mountain ranges, river systems, towns, roads and provincial and country boundaries. Mountain ranges (indicated by the dotted lines) are: A: the Sneeuberg; B: the Winterberg; C: the Stormberg; D: the southern Drakensberg. Collection sites for samples are indicated by the circled numbers. 1: Asante Sana Private Game Reserve; 2: Winterberg area, including the main Winterberg Peak, Klein Winterberg Peak and Katberg Pass; 3: Leeufontein Farm; 4: Naude's Nek Pass area.

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[2] Only 23 of the 25 birds were ringed – two escaped before they could be ringed, but left feathers from which DNA was successfully extracted.

DNA extraction, PCR and Sequencing

Total genomic DNA was extracted from the feather tips using an Invisorb spin tissue mini kit and the manufacturer’s recommended protocols. To amplify the mitochondrial section of the ND2 gene, 25 µl polymerase chain reactions (PCR) were performed using standard buffer, dNTP, $MgCl_2$ and *Taq* polymerase concentrations. Thermocycle profiles were: 94°C for 4 min, then 40 cycles of: 94°C for 1 min, 53°C for 1 min, and 72°C for 2 min, with a final extension of 72°C for 10 min and a 4°C soak. The primers sequences used for this were L5216 (5’-RGA KGA GAA RGC YAG GAT YTT) and H5766 (5’-GGC CCA TAC CCC GRA AAT G-3’) as suggested by Sorenson *et al*. (1999).

PCR products were purified and recovered using a MSB Spin PCRapace (250) cleanup kit. A standard dye terminator cycle sequence protocol was then performed, using the same primers and thermocycle profile of: 95°C for 1 min, then 30 cycles of: 96°C for 30 sec, 50°C for 15 sec, and 60°C for 4 min, with a final extension of 60°C for 3 min and a 4°C soak. Reaction products were precipitated using a sodium acetate (NaAC) and ethanol (100% and 70%) precipitation method, and sequenced using an Applied Biosystems 3100 genetic analyser. Complementary strands of each gene were aligned using SEQUENCHER v4.8 (Gene Codons Corperation, Ann Arbor, Michigan, USA).

Analyses

Phylogenetic relationships between haplotypes were examined using Neighbor Joining analysis. A Neighbor Joining tree was constructed using uncorrected P-distance values in MEGA v5.1 (Tamura *et al*. 2011). This was then analysed on three spatial scales: large scale – between the three main mountain areas (Sneeuberg, Winterberg and Stormberg and southern Drakensberg); medium scale – within the mountain ranges; and local scale – between boulder fields at a certain site (Asante Sana). For these analyses, the Stormberg and southern Drakensberg were grouped together, due to the fact that the Stormberg is to a large extent an extension of the Drakensberg (Hoare & Bredenkamp 2001; Clark *et al*. 2011b and c), and the two are not separated by some biogeographic divide (such as the Sneeuberg and Winterberg being separated by the Great Fish River valley).

Results

Phylogenetic Analyses

The ND2 data set comprised 494 base-pairs. A total of eleven haplotypes (Figure 3.2) were obtained from the entire range of collected samples (Figure 3.3). Seven of these were private haplotypes (numbers 2, 3, 6, 7, 8, 9 and 11), and the most common haplotype (number 1) was found in seven individuals. This single haplotype was present in birds right across the Eastern Cape Escarpment, from Asante Sana in the Sneeuberg to the Naude’s Nek area in the southern Drakensberg. Of the four non-private haplotypes, only haplotype 10 was found in birds from only one area. This was Asante Sana, where nearly half the samples were caught.

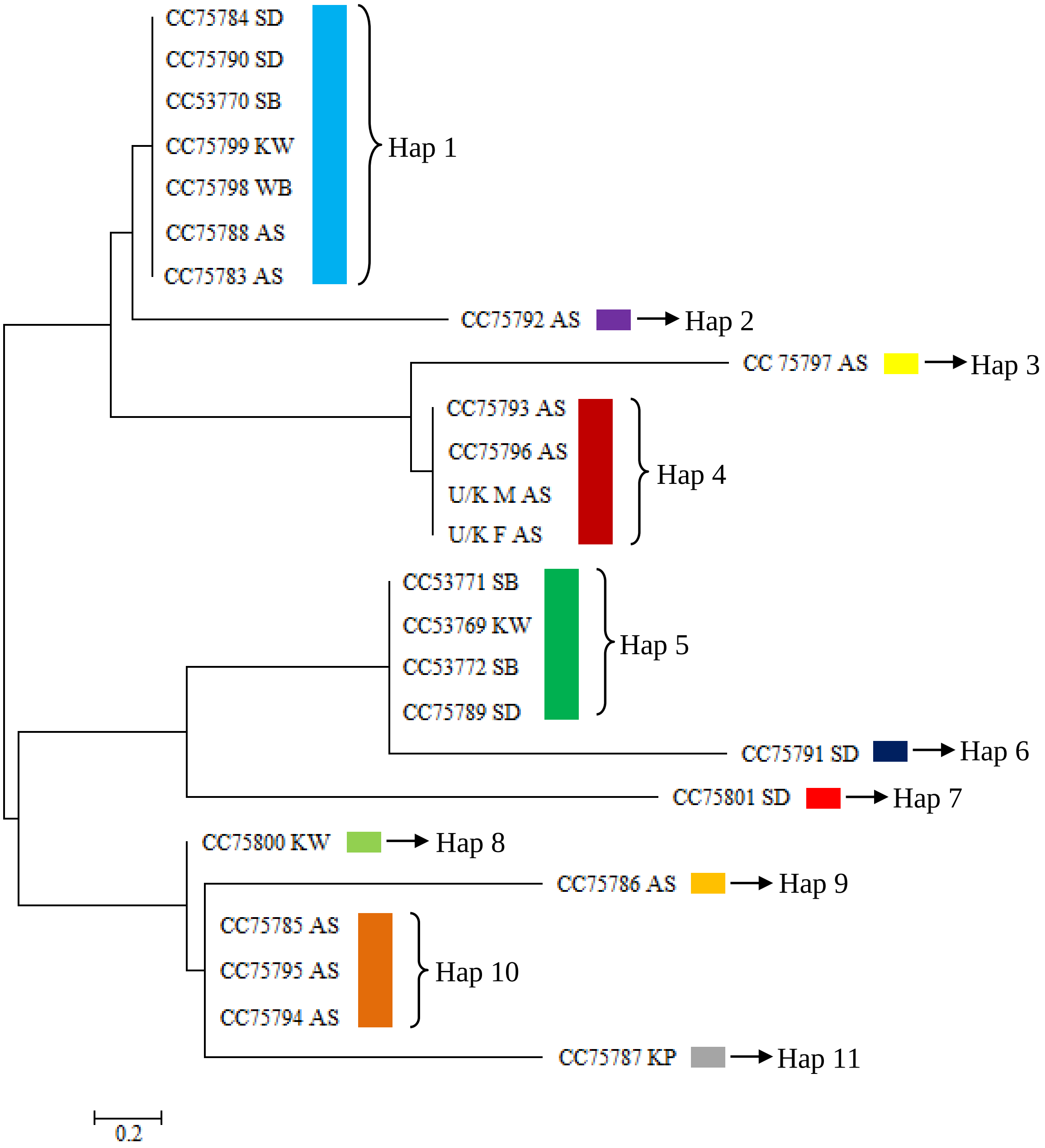

Figure 3.2: Mid-point rooted Neighbor Joining tree for all 25 samples caught during the study. Sample numbers refer to the ring numbers given to individual birds, and the two letter code that follows refers to the mountain area in which they were caught. AS = Asante Sana (Sneeuberg); WB = Winterberg Peak; KW = Klein Winterberg Peak; KP = Katberg Pass; SB = Stormberg; SD = Southern Drakensberg. U/K M and U/K F refer respectively to the "Unknown" (sampled, but not ringed) male and female individuals caught at Asante Sana. Each haplotype has been given a nominal number (1-11) and colour. The colours refer to the pie charts in Figures 3.4, 3.5, 3.6 and 3.7.

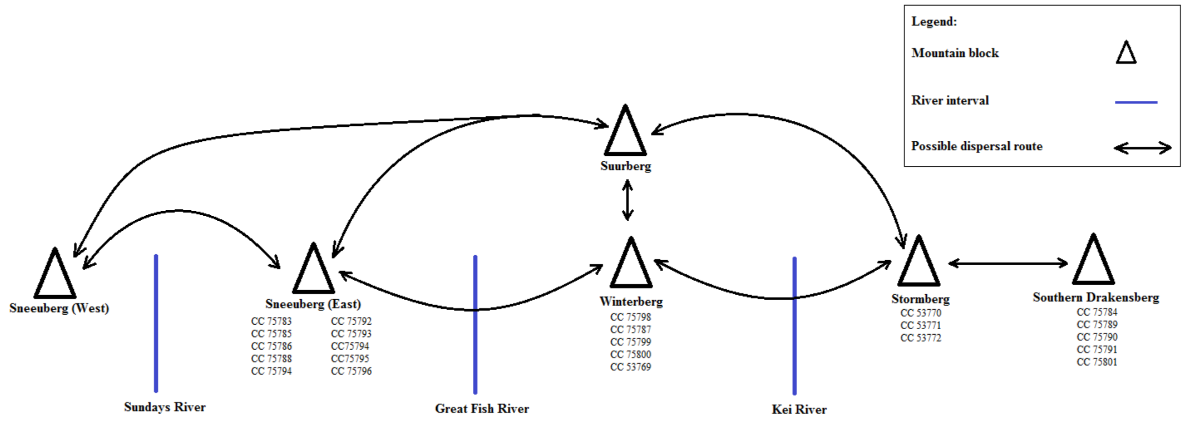

Figure 3.3: A schematic diagram of the Drakensberg rock-jumper's distribution in the Eastern Cape, showing important mountain ranges, river intervals and possible dispersal routes that the birds have taken. The individual ring number for each bird in each section is also shown. Two further birds, one male and one female, were caught, sampled, but not ringed in the Sneeuberg section.

Large Scale – Between Mountain Blocks

At the broadest scale, there is a single haplotype (haplotype 1) that is found in specimens from all collection areas (Figure 3.4). The only other trans-range haplotype is haplotype 5, which is shared by birds from the Winterberg, Stormberg and southern Drakensberg. All other haplotypes are either private haplotypes, or are present only in birds from a single area.

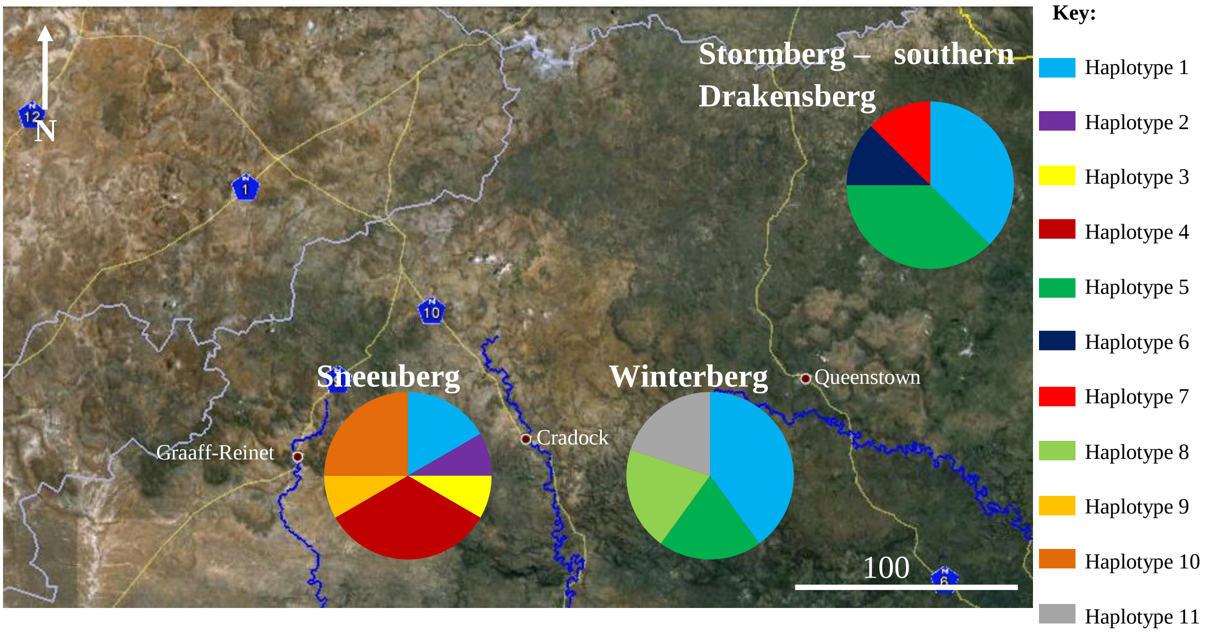

Figure 3.4: The spread of the eleven haplotypes across the three mountain areas of the southern Escarpment. The number of birds sampled in each section is: Sneeuberg = 12; Winterberg = 5; Stormberg – southern Drakensberg = 8.

Medium Scale – Within Mountain Blocks

Winterberg

The Winterberg represent the smallest sample size of the three main mountain blocks, with five birds being caught between the Main Winterberg Peak, the Klein Winterberg, and the Katberg Pass. These three areas showed a relatively high degree of variability, with the five individuals exhibiting four haplotypes. Two of these (haplotypes 8 and 11) were private haplotypes, with the other two being shared with birds in other mountain blocks.

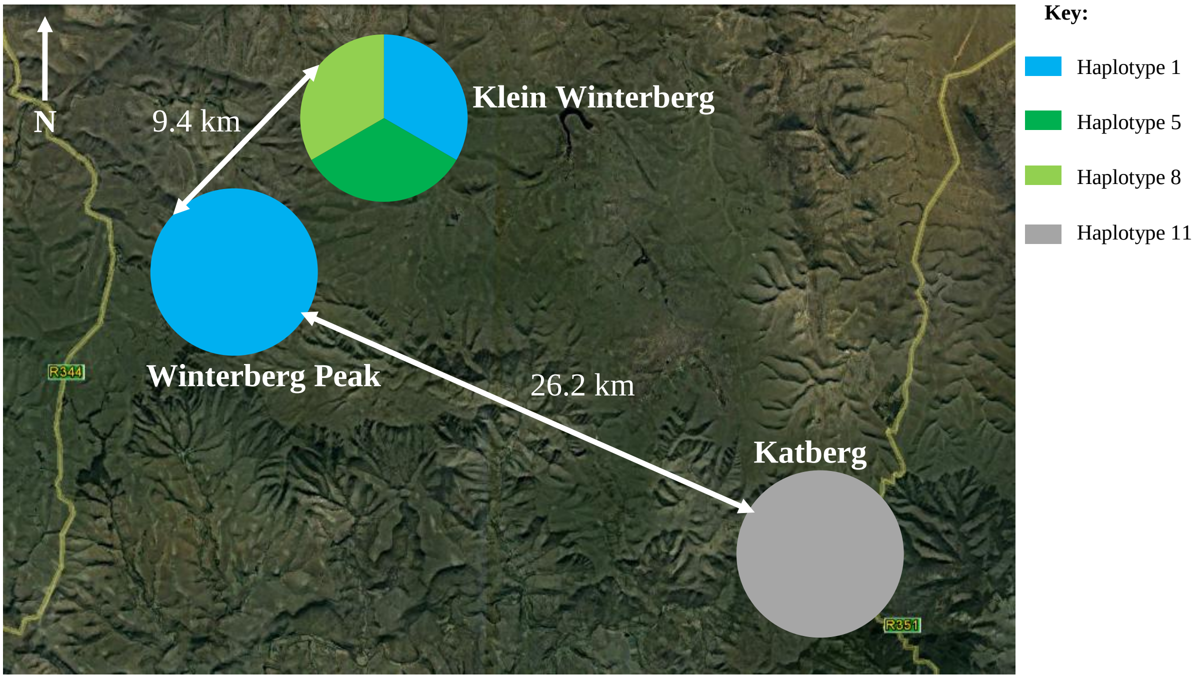

Figure 3.5: The spread of four haplotypes in the Winterberg mountain block. Only one bird was caught on the Winterberg Peak, and the Katberg Pass. Three birds were caught on the Klein Winterberg.

Stormberg and southern Drakensberg

These mountain blocks are represented by eight birds, three caught on the Leeufontein Farm in the Stormberg, and five from the Naude's Nek area in the southern Drakensberg (Figure 3.6). These two areas are furthest apart of all sites, but are separated only by distance and high mountains stretch fairly continuously from one to the other.

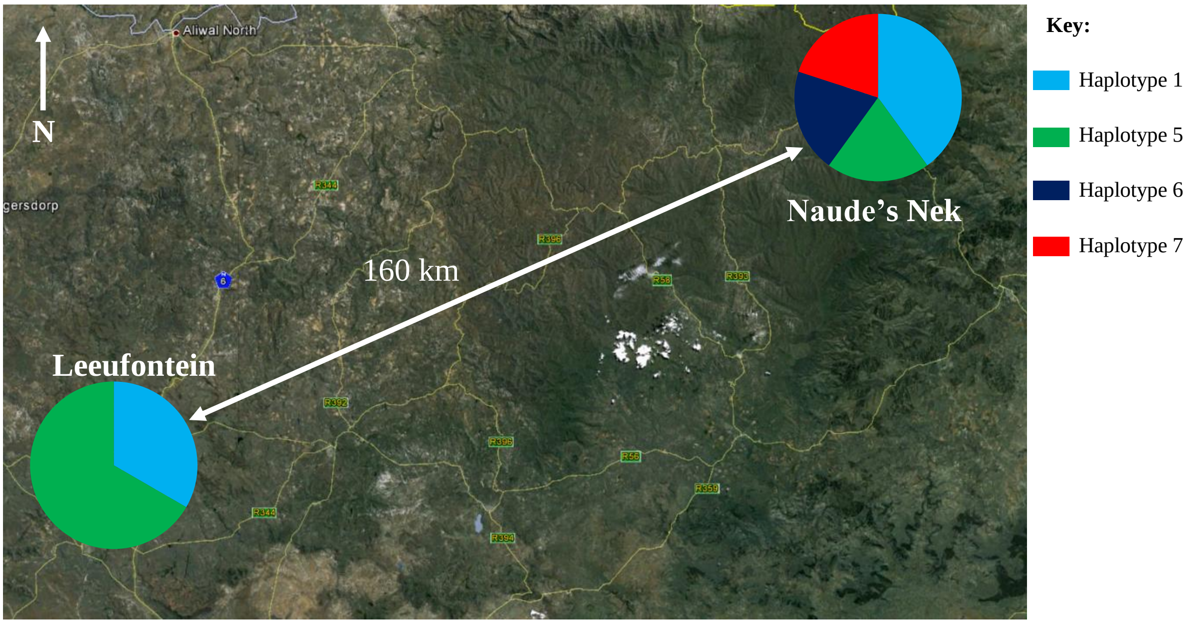

Figure 3.6: The spread of haplotypes across the Stormberg and southern Drakensberg mountain blocks. Three birds were caught at Leeufontein farm, and five in the Naude's Nek area.

Small Scale – Between Boulder Fields

Asante Sana

A total of twelve birds were caught at Asante Sana, in three boulder fields (Called Boulder Field 1, 2 and 3. Figure 3.7). Boulder field 1 contained four birds, Boulder field 2 contained just one bird, and Boulder field 3 contained seven.

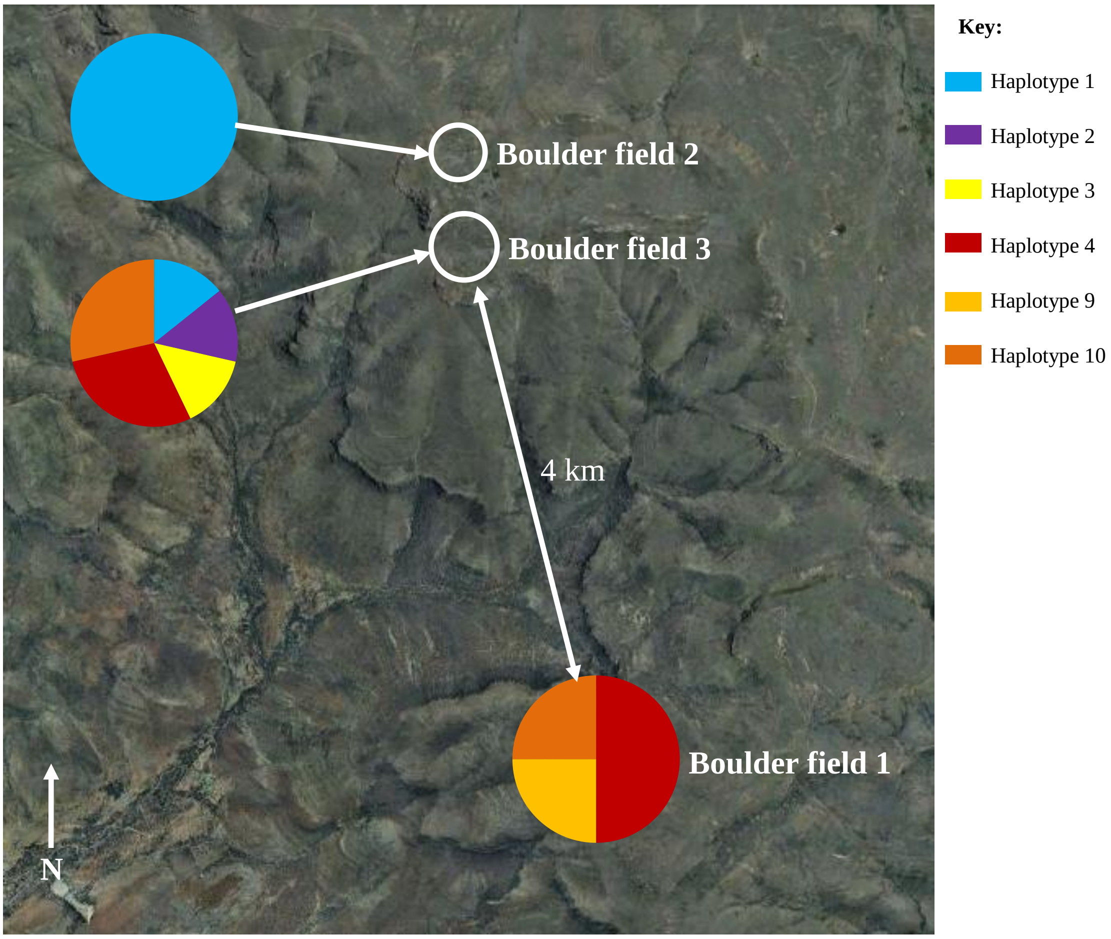

Figure 3.7: The spread of haplotypes across the Asante Sana boulder fields. Four birds were caught in Boulder field 1, one in Boulder field 2, and seven in Boulder field 3.

Discussion

The data suggests that there is, or has been some, gene flow between the major mountain blocks, with one haplotype (Haplotype 1) being common to all. This might represent an ancestral haplotype, since the substantial number of private haplotypes suggests that there has been mutation during isolation within each mountain block. Unfortunately, it is not possible with this limited data set to determine if these private haplotypes are really restricted to one region, and considerably more samples are needed to resolve whether isolation and lack of gene flow is ongoing or historical.

Of the eleven haplotypes present in the sampled birds, seven were private. Of these seven, only the bird caught at the Katberg Pass in the Winterberg represents the total birds sampled at that site. All other private haplotypes occurred in birds that were trapped close to, or in the same boulder fields, as bird exhibiting other haplotypes. Haplotype 1 is of particular interest, as it is contained in birds from all mountain blocks. In contrast, birds CC75795, CC75796 and CC75797 are all genetically distinct (Figure 3.3), but caught in the same boulder field (Boulder field 3 at Asante Sana) on the same day, between 12h00 and 12h50 in the afternoon. It is even likely that two of them were a breeding pair at the time. A similar case occurred with birds CC75799 and CC75800, both caught on the Klein Winterberg on the same day.

The lack of regional partitioning of genetic diversity shows either that the birds are (or have been) moving on a large spatial scale – some birds at Asante Sana have closer relatives in the Naude’s Nek area (at the other end of the Eastern Cape) than they do in the boulder field next door – or that the widespread ancestral haplotypes have not yet been lost as a consequence of genetic drift. The habits of these birds suggest that they are highly sedentary and do not move from their established territories and preferred boulder fields (as seen in Chapter 2), and it is unlikely that regular gene flow is possible under current conditions. However, gene flow may have occurred up until the end of last glacial maximum (LGM), which ended approximately 18 000 years ago (Lewis 2011). During that time, the climate in the region of the southern Escarpment was drier and cooler, and dominated by glacial and periglacial conditions (Meadows & Meadows 1988; Boelhouwers & Meiklejohn 2002; Thomas *et al*. 2002; Lewis 2011). The cooler conditions that dominate the high peaks of the southern Escarpment would have been much more extensive during that time, thereby decreasing the distance for effective dispersal. Indeed, this theory has been postulated before, when Clark *et al*. (2009; 2011c) suggested this as a potential mechanism for the floristic links between the CFR and DAC.

Faunal studies that can be used for comparative data are minimal. However, Davidson (2009) and Mataruse (2010) showed that the small mammal assemblages of the Sneeuberg are genetically isolated from the Drakensberg to the east, and the Cape mountains to the west. *Prestonella*, a rare genus of terrestrial snails, shows significant levels of genetic isolation even at a small scale, which is concurrent with its highly sedentary lifestyle (Fearon 2011). Although these are taxonomically very different to each other, and to the rock-jumper, they do at least suggest that the LGM enabled the current distribution of these taxa. Studies on the afrotemperate forests of KwaZulu-Natal show that the response of vertebrate taxa to large scale, historical climatic events (such as the LGM) is largely based on their relative mobility, with birds showing distribution patterns defined by post-LGM dispersal, while mammals and frogs exhibit higher degrees of climate-driven extinction (Lawes *et al*. 2007). Comparable work in the afromontane forests of the Bamenda highlands in Cameroon show similar patterns, with the expansion and contraction of suitable habitat caused by long term climate oscillations bringing on island-like distribution patterns in the local avifaunal endemics (Reif *et al*. 2006).

CHAPTER 4

GENERAL CONCLUSION, CONSERVATION AND FUTURE RESEARCH

This thesis provides the first detailed field data on the Drakensberg rock-jumper (*Chaetops aurantius*), a little known high-altitude bird endemic to the southern Escarpment of South Africa and Lesotho. The majority of published knowledge that is specific to this species is based on incidental and opportunistic observations and is not backed by quantitative or even photographic evidence. Secondly, no genetic data has ever been collected for this species. The fact that it lives across a disjointed mountain habitat in the Eastern Cape, and forms one of the stronger faunal links between the Drakensberg Alpine Centre (DAC) and the Cape Floristic Region (CFR) makes it ideal for a phylogeographic study.

The first aspect of this study was undertaken to assess the knowledge gaps of the basic ecology of the rock-jumper: what habitat it lives in, how it uses that habitat, its diet, foraging tactics, and interactions with other species. Results indicate that (certainly once it reaches maturity) this bird is highly sedentary, living in pairs or small family groups while maintaining a year-round territory. Birds appear to be exclusively insectivorous, and their movements and foraging tactics are reflected in the terrestrial nature of the insects they eat.

Rock-jumpers also show a strong altitudinal restriction, only living above an elevation of around 1500 m. This appears to have an influence over their habitat requirements, with birds living close to this altitude (notably in the Sneeuberg and Winterberg) being strongly tied to boulder fields dominated by grassy vegetation. At higher altitudes (in the Stormberg *c.* 2000 m, and southern Drakensberg *c.* 2500 m), this restriction to boulder fields seems to diminish. A possible explanation may be the effect of human farming activities – sites in the Stormberg and southern Drakensberg are heavily grazed, and the short grass may increase foraging success for the birds, and enable them to move quite far (tens to hundreds of meters) from their normally boulder-dominated territories.

The second aspect of this study was undertaken to analyse the genetic diversity of the rock-jumper, across its distribution range within the Eastern Cape. Although only twenty five individuals were analysed, the data suggests that birds are currently living in isolated refugia, which were historically linked. The likely explanation of this is that during the last glacial maximum (LGM), the southern escarpment was cooler and drier, conditions which are favourable to the birds, promoting effective genetic exchange between the mountain blocks they now occupy.

Conservation

Although currently listed as non-threatened (Hockey *et al*. 2005), the Drakensberg rock-jumper “has projections of decrease in both total abundance and range extent that are amongst the greater projected decreases” (Huntley *et al*. 2012, p. 675). Simmons *et al*. (2004) projects that it may lose as much as 69% of its current habitat by 2050. The projections by Huntley *et al*. (2012) show a decline in range to encompass the Stormberg, and parts of north-eastern Lesotho and the KwaZulu-Natal Drakensberg by 2085. This is largely due in turn to the projected shifts in climate: a delayed onset and early cessation of the rainy season, and increase in drought severity over the semiarid parts of southern Africa (Shongwe *et al*. 2009). Barnes (1998) suggested that 80% of the rock-jumpers range was in Lesotho, a figure which has subsequently changed significantly, given the sightings of the bird in the Sneeuberg and Winterberg in recent years (this study; Clarke *et al*. 2012). However, if these areas are lost, then Barnes’ figure may hold true.

A twenty year study by Visser *et al*. (2006) on the great tits (*Parus major*) showed how the birds have timed their reproductive cycles to coincide with seasonal periods where caterpillars are in greatest abundance. A modelled change in climatic conditions led to a shift in caterpillar biomass, which in turn caused a shift in the laying dates of the birds. As rock-jumpers appear to be generalist and opportunistic feeders (Chapter 2), taking whatever is available, rather than restricting themselves to a specific prey item, they may follow a similar path to the great tits and modify its breeding season to accommodate new conditions (Simmons *et al*. 2004).

Another potential threat will be from dramatic changes in vegetation regimes. It is possible that these will occur very quickly and leave significant portions of montane environment un-inhabitable for many current species. However, a notable cause in this case is not the onset of climate change, but the invasion of alien species (Clark *et al*. 2011a and b). Of particular concern is a South American grass species *Nassella trichotoma*, currently occupying “large tracts” of the Boschberg and Groot-Bruintjieshoogde (eastern Sneeuberg), with infestations that “currently run into the hundreds of hectares” and showing all signs of further expansion if no action is taken (Clark *et al*. 2011a, p. 98). Exactly how specific animal species will be affected by such a change is not known, and would largely depend on the animal or animal group in question. In the rock-jumper’s case, the role of helpers in breeding cycles may become more pronounced, and territory sizes may change.

The opportunistic foraging of rock-jumpers does suggest that – at least from a food requirement perspective – they will be unaffected by climate change (Simmons *et al*. 2004). Whether their habitat heats up, cools down, becomes wetter, drier or remains constant, insects (either indigenous or invasive) will still be available in one assemblage form or another (Chown *et al*. 2007). Insect specialists, such as the ground woodpecker (which almost exclusively eats ants: Oatley *et al*. 1989), will be more seriously affected by a shift in insect populations. Generalists (like the rock-jumper and the Sentinel rockthrush) will be more likely to adapt (Simmons *et al*. 2004; Chown *et al*. 2010).

An important area of concern is the lack of established conservation areas along the southern Escarpment (Osborne & Tigar 1992; Coetzee *et al*. 2009; Clark *et al*. 2011b). Despite the overall length of this feature, it is a narrow and disjointed mountain range, with steep environmental gradients and restricted stretches of any particular habitat (Clark *et al*. 2011b). The requirement for the establishment of conservancies and parks along these mountain corridors is becoming more and more apparent, particularly in Lesotho (Osborne & Tigar 1992; Barnes 1998; Clarke *et al*. 2011b).

The use of genetic studies in avian demography can assist greatly in helping categorise species and prioritise conservation efforts (Haig *et al*. 2011; Krishnamurthy & Francis 2012). These can address issues in taxonomy, such as evolutionary and geographic boundaries of species, the change in biodiversity in response to climate change, and prioritising biodiversity conservation using phylogenetic diversity; issues in populations, such as effective population size and structure, shifts in gene flow over time, strategies for maintaining genetic diversity in small populations, degrees of population connectivity; and issues at landscape levels, such as the effect of geographical features on genetic diversity and population structure, the changes in phylogenetic patterns in response to climate change, and the effect of pollution or other contaminants on populations or life stages (Haig *et al*. 2011; Krishnamurthy & Francis 2012).

Future Research

Ecology

Although this study has led to the diet and feeding ecology of the rock-jumper being better understood, fundamental components of its breeding ecology remain unknown. This includes the duration of egg incubation, whether both parents perform this task, the temperatures of incubation and how they compare to the surrounding environment, fledging timing, the role that close relatives play as helpers in feeding nestlings and fledglings, who these helpers are (young adults from previous breeding periods, kin of the parents, or more distant relatives), and how long the fledglings remain in the care of their parents.

Although all birds caught at Asante Sana for this study were colour ringed (as well as one at Naude’s Nek), all were adults with the exception of one possible juvenile. Colour ringing nestlings would provide very valuable information with regards to dispersal distance: are they moving to a territory adjacent to their natal range? If so, the near-proximity to close relatives would obviously cause potential inbreeding. Are they moving further afield? The boulder field habitats rock-jumpers breed in are seldom very extensive, and young adults may need to move several kilometres before they find space in which to establish their own territories. The possibility that they are moving even further (tens to hundreds of kilometres) must also not be discounted if indeed the birds are moving between mountain blocks.

Another area for further study and experimentation concerns the breeding success of rock-jumpers with regards to their family group size, and the role the helpers play in rearing young. As rock-jumpers can be considered the African equivalent of an alpine species and live in a physiologically demanding environment: the addition of helpers to the breeding strategy may be a measure to counteract this effect (Martin & Wiebe 2004).

Phylogeography and genetic diversity

The obvious point to make here concerns the small sample size of this study: rock-jumpers are elusive birds at the best of times, and difficult to trap successfully.[3] An increase in sample size would obviously increase the resilience of the phylogeographic data. This would ideally be done in three ways:

1. Returning to the sites used for this study, and collecting genetic samples from more birds in those areas.
2. Sampling birds from the "other half" of its distribution range – Lesotho and the KwaZulu-Natal Drakensberg.
3. Expanding the genetic analyses to other genes, such as cytochrome-*b*.

Apart from enabling a better understanding of the potential genetic isolation of these birds by increasing the genetic sample size, it should also (using microsatellite studies) be possible to accurately determine family relations in the "small family groups" that rock-jumpers live in.

Finally, these genetic samples might be used in resolving the longstanding *Chaetops* taxonomic debate: defining its closest relatives and where it fits into the Afrotropical passerine tree.

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[3] A noteworthy statistic for this study is that the ratio of field hours to birds caught averaged out at eighty seven hours per bird!

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APPENDIX 1

TRAPPING THE DRAKENSBERG ROCK-JUMPER

Introduction

Given that the Drakensberg rock-jumper (*Chaetops aurantius*) is a particularly difficult species to catch and sample, I feel that it is necessary to provide some background into their trapping if further work is to be conducted with any ease. As a result, the purpose of this appendix will be as a “how-to” guide for future researchers, wishing to capture this (or indeed similar) species.

Traps

The traps used for the purposes of this thesis were standard clap traps (figure 5.1). These are constructed from a square wire frame (34 x 34 cm), attached to a spring loaded secondary frame. Both of these support a single layer of nylon diamond mesh. The secondary frame is held under tension by a trigger mechanism, which, when tripped, releases the frame, causing it to flip over the bird, encasing it between the two layers of mesh. The trigger mechanism is loaded with some form of bait or lure, which when pecked by the bird will cause it to trip. This is located at the centre of the trap, so that when the mechanism is set off, the bird is generally positioned away from the outer frame and out of harm's way.

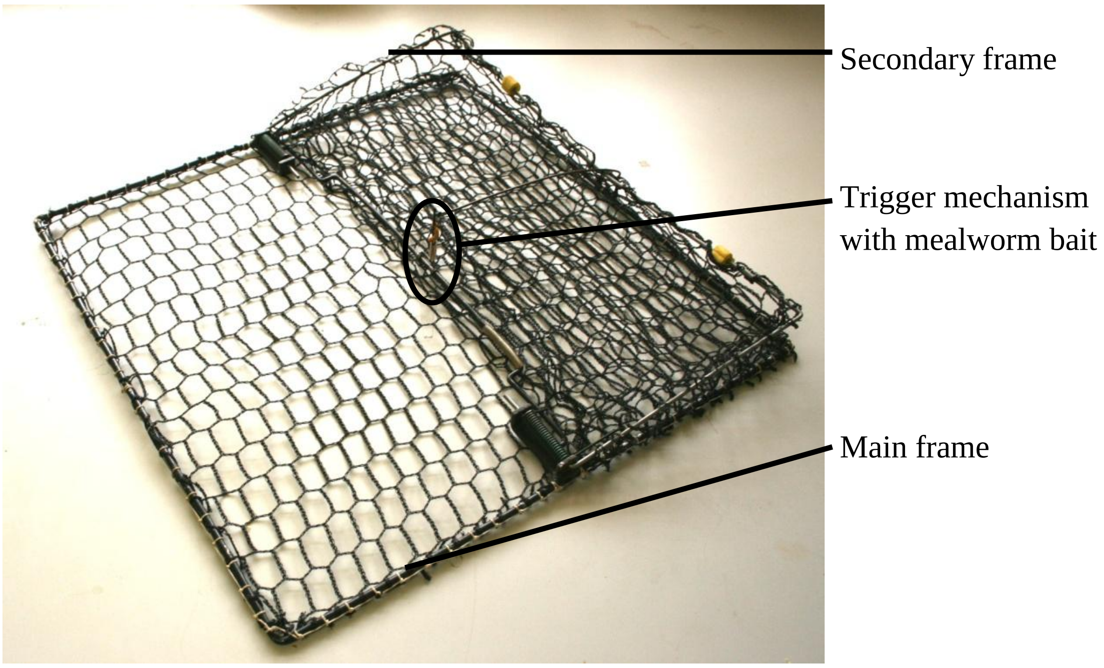

Figure 5.1: The 34 x 34 cm clap trap used for the duration of this project.

Placement of Traps

It is up to the individual observing the traps, and the terrain in which the trapping session will take place which will determine the number of traps used. An observation point should be chosen based on how many suitable trapping locations can be seen from it: once the traps are set up, the observer should stay at the observation point and moving as little as possible as any movement will disturb the birds. Bearing in mind that rock-jumpers in particular perch on rocks and outcrops, and never on bushes or shrubs, traps should be placed on flat boulders, ideally next to some sort of perch from which the trap and its bait can be clearly seen by a bird. Traps should also be placed close enough to the observer so that once a bird is caught, it can be retrieved fairly quickly and will not lie struggling in the trap for longer than is strictly necessary. However, placing traps too close to the observation point will mean that birds will not approach them.

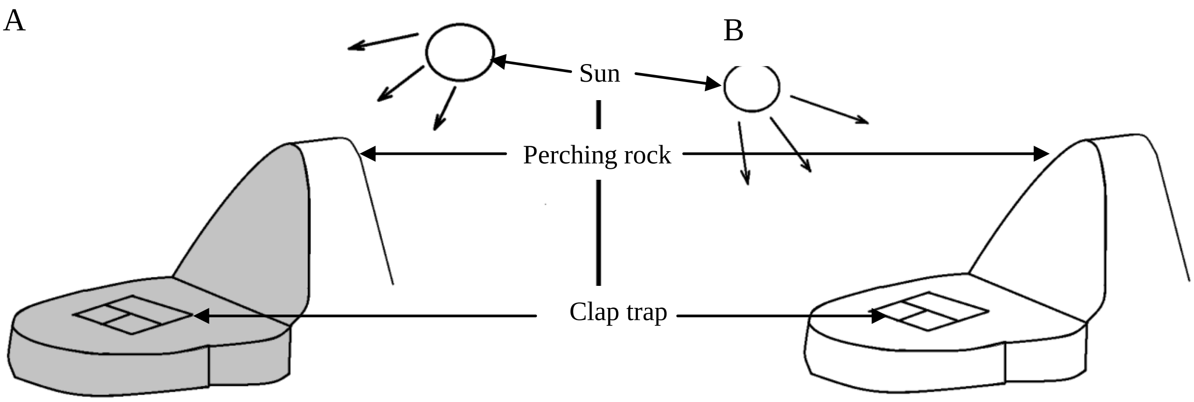

Figure 5.2: An ideally placed clap trap – a flat rock, with a perch nearby. In A, the trap is shaded, while in B, it is fully illuminated by the sun.

A further consideration is the exposure of the trap to sunlight. If the trap is placed in full sun (figure 5.2B), it is easier for the bird to see – and therefore avoid – this foreign object. However, the bait will also be easier to see. If it is placed on a boulder in the shade (figure 5.2A), the dark mesh of the trap will be somewhat camouflaged, but the bait will also be harder for the bird to see. Because of this, it is important to consider both the time of day, and the bait used.

If a full day of trapping is planned, the traps will be set up fairly early in the morning, and the observer should retreat to an observation point. As the day progresses, the sun will move across the sky and traps that were in shade will be in sun and vice-versa.

Bait

The bait used will also play an important role. Having tried using earthworms, beetles, grasshoppers and butterflies as bait, I have found that mealworms (*Tenebrio* sp.) work best. Firstly they are relatively pale in colour (and thus easier to see if the trap is in shade), and secondly have amazing longevity – those used as bait can survive in the trigger mechanism of a trap for up to three days. Because of this they not only sit in the trap, but crucially *move*, enticing curious birds to at least give them a peck.

The Use of Call Recordings

A final consideration is the use of recorded calls, which are played back and used to entice or at least elicit a response from the target group. With rock-jumpers, I have found very mixed responses. Either the birds come out and respond fairly rapidly, or they ignore the noise altogether. Having used the same equipment and the same call, my only explanation is that this has to do with the phase of their breeding cycle. I have noted that birds (of both sexes) respond rapidly to a recorded call just before, and during their breeding season. This is a time when they are particularly active in establishing and maintaining their territories. At other times they may show no interest in play-back of recorded calls.

APPENDIX 2

THE ND2 ALIGNMENTS FOR THE DRAKENSBERG ROCK-JUMPER

This appendix shows the ND2 alignments of the 25 sampled Drakensberg rock-jumpers (including the un-ringed male and female birds, caught at Asante Sana). The number codes refer to the ring numbers of the birds, and the letter codes that follow refer to the location in which the individuals were caught: AS – Asante Sana; WB – Main Winterberg peak; KW – Klein Winterberg peak; KP – Katberg Pass; SB – Stormberg (Leeufontein Farm); SD – Southern Drakensberg (Naude's Nek area).

Samples are arranged according to Figure 3.2.

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75784SD CAGCCTCCTAGGGCTACGGAGAGAATAGCCATGTAGGTTAGTGGGGTGGGGTCGAGGGAG
75790SD CAGCCTCCTAGGGCTACGGAGAGAATAGCCATGTAGGTTAGTGGGGTGGGGTCGAGGGAG
53770SB CAGCCTCCTAGGGCTACGGAGAGAATAGCCATGTAGGTTAGTGGGGTGGGGTCGAGGGAG
75799KW CAGCCTCCTAGGGCTACGGAGAGAATAGCCATGTAGGTTAGTGGGGTGGGGTCGAGGGAG
75798WB CAGCCTCCTAGGGCTACGGAGAGAATAGCCATGTAGGTTAGTGGGGTGGGGTCGAGGGAG
75788AS CAGCCTCCTAGGGCTACGGAGAGAATAGCCATGTAGGTTAGTGGGGTGGGGTCGAGGGAG
75783AS CAGCCTCCTAGGGCTACGGAGAGAATAGCCATGTAGGTTAGTGGGGTGGGGTCGAGGGAG
75792AS CAGCCTCCTAGGGCTACGGAGAGAATAGCCATGTAGGTTAGTGGGGTGGGGTCGAGGGAG
75793AS CAGCCTCCTAGGGCTACGGAGAGAATAGCCATGTAGGTTAGTGGGGTGGGGTCGAGGGAG
75796AS CAGCCTCCTAGGGCTACGGAGAGAATAGCCATGTAGGTTAGTGGGGTGGGGTCGAGGGAG
UKMAS   CAGCCTCCTAGGGCTACGGAGAGAATAGCCATGTAGGTTAGTGGGGTGGGGTCGAGGGAG
UKFAS   CAGCCTCCTAGGGCTACGGAGAGAATAGCCATGTAGGTTAGTGGGGTGGGGTCGAGGGAG
75789SD CAGCCTCCTAGGGCTACGGAGAGAATAGCCATGTAGGTTAGTGGGGTGGGGTTGAGGGAG
75791SD CAGCCTCCTAGGGCTACGGAGAGAATAGCCATGTAGGTTAGTGGGGTGGGGTTGAGGGAG
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53769KW CAGCCTCCTAGGGCTACGGAGAGAATAGCCATGTAGGTTAGTGGGGTGGGGTTGAGGGAG
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75787KP CAGCCTCCTAGGGCTACGGAGAGAATAGCCATGTAGGTTAGTGGGGTGGGGTCGAGGGAG
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75797AS ????????????????????????????????????????????????????????????
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75790SD GGAGAGGTCATAAAGAGAAGGGCGATGGGGGGGAGTTTTATGATGGTGGATAAGAGGAGC
53770SB GGAGAGGTCATAAAGAGAAGGGCGATGGGGGGGAGTTTTATGATGGTGGATAAGAGGAGC
75799KW GGAGAGGTCATAAAGAGAAGGGCGATGGGGGGGAGTTTTATGATGGTGGATAAGAGGAGC
75798WB GGAGAGGTCATAAAGAGAAGGGCGATGGGGGGGAGTTTTATGATGGTGGATAAGAGGAGC
75788AS GGAGAGGTCATAAAGAGAAGGGCGATGGGGGGGAGTTTTATGATGGTGGATAAGAGGAGC
75783AS GGAGAGGTCATAAAGAGAAGGGCGATGGGGGGGAGTTTTATGATGGTGGATAAGAGGAGC
75792AS GGAGAGGTCATAAAGAGAAGGGCGATGGGGGGGAGTTTTATGATGGTGGATAAGAGGAGC
75793AS GGAGAGGTCATAAAGAGAAGGGCGATGGGGGGGAGTTTTATGATGGTGGATAAGAGGAGC
75796AS GGAGAGGTCATAAAGAGAAGGGCGATGGGGGGGAGTTTTATGATGGTGGATAAGAGGAGC
UKMAS   GGAGAGGTCATAAAGAGAAGGGCGATGGGGGGGAGTTTTATGATGGTGGATAAGAGGAGC
UKFAS   GGAGAGGTCATAAAGAGAAGGGCGATGGGGGGGAGTTTTATGATGGTGGATAAGAGGAGC
75789SD GGAGAGGTCATAAAGAGAAGGGCGATGGGGGGGAGTTTTATGATGGTGGATAAGAGGAGC
75791SD GGAGAGGTCATAAAGAGAAGGGCGATGGGGGGGAGTTTTATGATGGTGGATAAGAGGAGC
53772SB GGAGAGGTCATAAAGAGAAGGGCGATGGGGGGGAGTTTTATGATGGTGGATAAGAGGAGC
53771SB GGAGAGGTCATAAAGAGAAGGGCGATGGGGGGGAGTTTTATGATGGTGGATAAGAGGAGC
53769KW GGAGAGGTCATAAAGAGAAGGGCGATGGGGGGGAGTTTTATGATGGTGGATAAGAGGAGC
75786AS GGAGAGGTCATAAAGAGAAGGGCGATGGGGGGGAGTTTTATGATGGTGGATAAGAGGAGC
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75795AS GGAGAGGTCATAAAGAGAAGGGCGATGGGGGGGAGTTTTATGATGGTGGATAAGAGGAGC
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75787KP GGAGAGGTCATAAAGAGAAGGGCGATGGGGGGGAGTTTTATGATGGTGGATAAGAGGAGC
75800KW GGAGAGGTCATAAAGAGAA?GGCGATGGGGGGGAGTTTTATGATGGTGGATAAGAGGAGC
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75784SD CCGGTGATTAAAGGTGAGCCTTGTATGACTTCTGGGAATCAGAAGTGGAAGGGAGCTAGA
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53770SB CCGGTGATTAAAGGTGAGCCTTGTATGACTTCTGGGAATCAGAAGTGGAAGGGAGCTAGA
75799KW CCGGTGATTAAAGGTGAGCCTTGTATGACTTCTGGGAATCAGAAGTGGAAGGGAGCTAGA
75798WB CCGGTGATTAAAGGTGAGCCTTGTATGACTTCTGGGAATCAGAAGTGGAAGGGAGCTAGA
75788AS CCGGTGATTAAAGGTGAGCCTTGTATGACTTCTGGGAATCAGAAGTGGAAGGGAGCTAGA
75783AS CCGGTGATTAAAGGTGAGCCTTGTATGACTTCTGGGAATCAGAAGTGGAAGGGAGCTAGA
75792AS CCGGTGATTAAAGGTGAGCCTTGTATGACTTCTGGGAATCAGAAGTGGAAGGGAGCTAGA
75793AS CCGGTGATTAAAGGTGAGCCTTGTATGACTTCTGGGAATCAGAAGTGGAAGGGAGCTAGA
75796AS CCGGTGATTAAAGGTGAGCCTTGTATGACTTCTGGGAATCAGAAGTGGAAGGGAGCTAGA
UKMAS   CCGGTGATTAAAGGTGAGCCTTGTATGACTTCTGGGAATCAGAAGTGGAAGGGAGCTAGA
UKFAS   CCGGTGATTAAAGGTGAGCCTTGTATGACTTCTGGGAATCAGAAGTGGAAGGGAGCTAGA
75789SD CCGGTGATTAAAGGCGAGCCTTGTATGACTTCTGGGAATCAGAAGTGGAAGGGAGCTAGA
75791SD CCGGTGATTAAAGGCGAGCCTTGTATGACTTCTGGGAATCAGAAGTGGAAGGGAGCTAGA
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75799KW CCTAGTTTTATAGCAATGGCGGTAGTTAGGATTAAGCAGGCTGTTGGGTGGGATATTTGG
75798WB CCTAGTTTTATAGCAATGGCGGTAGTTAGGATTAAGCAGGCTGTTGGGTGGGATATTTGG
75788AS CCTAGTTTTATAGCAATGGCGGTAGTTAGGATTAAGCAGGCTGTTGGGTGGGATATTTGG
75783AS CCTAGTTTTATAGCAATGGCGGTAGTTAGGATTAAGCAGGCTGTTGGGTGGGATATTTGG
75792AS CCTAGTTTTATAGCAATGGCGGTAGTTAGGATTAAGCAGGCTGTTGGGTGGGATATTTGG
75793AS CCTAGTTTTATAGCAATGGCGGTAGTTAGGATTAAGCAGGCTGTTGGGTGGGATATTTGG
75796AS CCTAGTTTTATAGCAATGGCGGTAGTTAGGATTAAGCAGGCTGTTGGGTGGGATATTTGG
UKMAS   CCTAGTTTTATAGCAATGGCGGTAGTTAGGATTAAGCAGGCTGTTGGGTGGGATATTTGG
UKFAS   CCTAGTTTTATAGCAATGGCGGTAGTTAGGATTAAGCAGGCTGTTGGGTGGGATATTTGG
75789SD CCTAGTTTTATAGCAATGGCGGTAGTTAGGATTAAGCAGGCTGTTGGGTGGGATATTTGG
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APPENDIX 3

PREVIOUSLY PUBLISHED WORK

Morris, D.B., Craig, A.J.F.K. & Barker, N.P. The Drakensberg rock-jumper – interchange between isolated populations? in: The 14th Meeting of the Pan-African Ornithological Congress, Arusha, Tanzania: 14-21 October 2012.

Abstract:

The two southern African rockjumper species represent an ancient Afrotropical passerine radiation, with no close relatives within this sub-region. The Drakensberg Rockjumper *Chaetops aurantius* occurs in the Drakensberg mountains of South Africa and Lesotho, extending westwards along the Great Escarpment of central South Africa. This escarpment forms a non-continuous mountain chain along the edge of the elevated inland plateau. Our study sites focus on this region, with comparative data from the Drakensberg population. Drakensberg Rockjumpers are recorded only above 1500 m, and remain at high altitudes throughout the year. Away from the central mountain massif, populations are thus highly fragmented, often on isolated summits outside of formally protected areas. The birds appear to be dependent on insect food, and occupy year-round territories in patches of suitable habitat – boulder fields on grassy slopes. There is no good evidence of long-distance dispersal, and both the insect fauna and the flora of the Great Escarpment show significant endemicity. These isolated populations are thus highly vulnerable to local extinction, whether as a result of human impact or through habitat modification induced by progressive climate change.

Clark, V.R., Perera, S.J., Stiller, M., Stirton, C.H., Weston, P., Stoev, P., Coombs, G., Morris, D.B., Ratnayake-Perera, D., Barker, N.P. & McGregor, G.K. 2013. A rapid multi-disciplinary biodiversity assessment of the Kamdebooberge (Sneeuberg, Eastern Cape, South Africa): Implications for conservation. *SpringerPlus* **1**: 56-65.

Abstract:

Botanical work since 2008 on the Sleeping Giant section of the Kamdebooberge (Sneeuberg mountain complex, Eastern Cape, South Africa) has indicated that these mountains may be of significant conservation value. Accordingly, a rapid multi-disciplinary biodiversity assessment was undertaken in January 2011, focussing on plants, tetrapod vertebrates and leaf-hoppers. The botanical results confirm the Kamdebooberge as being of high botanical conservation value, hosting three strict endemics, healthy populations of five other Sneeuberg endemics, and fynbos communities comprising species not found elsewhere in the Sneeuberg. The Kamdebooberge are important for herpetofauna (excluding Serpentoids) and mammals, hosting several range-restricted and regional endemics. The expedition uncovered three new leafhopper species, together with several species previously known from the Cape Floristic Region. Further detailed faunal work may provide further interesting results from these mountains, which show a high conservation value unique to the southern Escarpment.