

INDIVIDUAL AND INTER-POPULATION VARIATION IN AFRICAN ROCK PIPIT *ANTHUS CRENATUS* SONGS

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KEYWORDS

African Rock Pipit, *Anthus crenatus*, vocalizations, song variation, populations, central South Africa

ABSTRACT

African Rock Pipit *Anthus crenatus* (ARP) songs were studied in the Free State, Eastern Cape and Lesotho between March 1995 and November 2007. ARP song comprises a two-syllable “*whee-preeuuu*” vocalization, repeated during a singing bout. Syllable 1 (S1) is a drawn-out whistle while syllable 2 (S2) is a more complex trill, consisting of up to 4 sub-types (S2a–d) with varying numbers of notes in each sub-type. Three song variations are classified based on differences in S2: (1) S2 comprised mainly of a trill at a constant frequency; (2) S2 has a trill with a progressively descending frequency; and (3) starts with a descending trill, followed by a trill at a constant frequency. Duration of song phrases ($x = 1.34$ sec; $n = 1470$) and intervals between song phrases ($x = 5.43$ sec; $n = 1263$) varied considerably between individuals and between the different populations. Sonograms of song phrases from different localities also indicate considerable variation in the structure of the song components. Principal component analysis indicates significant differences in S2a and S2b between different localities. Differences between songs at different localities may be attributed to isolation of ARP populations on hilly areas, separated by unsuitable plains habitat.

INTRODUCTION

The African Rock Pipit *Anthus crenatus* (ARP) is locally distributed in the mountainous interior of South Africa and Lesotho where it prefers rocky outcrops with open grass patches on mountain hillsides with scattered trees and rocks (Clancey 1997, Voelker 2005, Peacock 2006). ARPs are mostly first located by their characteristic song given from an elevated perch (de Swardt 2006, Peacock 2006).

ARP song is described as a sweet, two-syllable “*whee-prreeuu*”, repeated several times, with the second note somewhat trilled (Voelker 2005). Peacock (2006) noted a number of song variants, including a stuttering rattle in the second syllable. Sonographic analysis of ARP songs recorded since 1995 in the Free State, the Eastern Cape and Lesotho during this study indicated the occurrence of both individual and inter-population song variation; these song variations are now described for the first time.

STUDY AREA & METHODS

ARP songs ($n = 56$ singing bouts) were recorded from 22 localities in the Free State, Eastern Cape and Lesotho between March 1995 and November 2007 (Fig. 1). In these areas, ARPs occur on rocky hills with large boulders, surrounded by flat, karroid or grassland vegetation. Preferred habitat includes

scattered bushes with sufficient grass cover for foraging and breeding.

Pipit vocalizations were tape-recorded with a Marantz CP130 cassette recorder, using a Sennheiser MKH 416 TU-3 directional microphone. A commercially available recording (Gillard 1983) or songs recorded from the study sites were sometimes played back to locate males and to observe responses. This was done especially during winter when the birds were more difficult to locate. Vocal analysis and sonogram preparation was done using Adobe Audition 2.0 (Adobe Systems Incorporated 2005) and Avisoft Lite (Raimund Specht, Berlin). The following sonographic measurements were taken for statistical analysis: the interval between song phrases, the duration of song phrases, syllable durations (S1 & S2), duration of the components in S2 (S2a–d), number of notes comprising S2a–d and their frequency ranges. These data were analyzed separately for the three song types identified (see results). In addition, detailed measurements (number of notes, frequency ranges at the beginning and end of component notes) of S2a and S2b were measured for principal component analysis (PCA) between the different populations. ANOVA tests were also performed on the duration and number of notes in S2a and S2b as these characteristics showed the most variation. The song phrase statistics were analyzed with Statistica v. 6 (StatSoft Inc., Tulsa, USA).

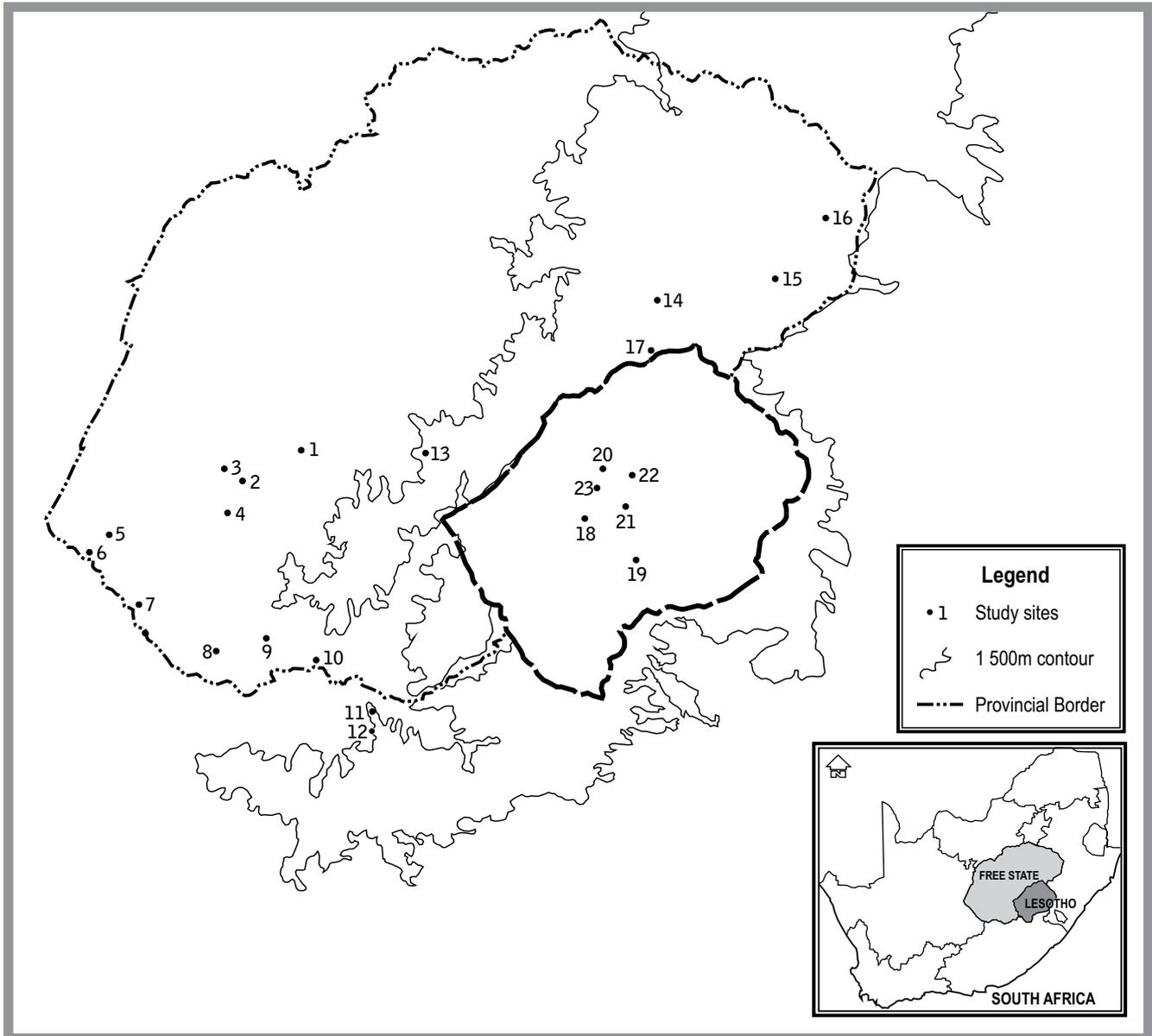


Fig. 1. Map showing locations at which African Rock Pipit *Anthus crenatus* vocalizations were recorded in the Free State, Lesotho and Eastern Cape between March 2005 and November 2007. The 1500 altitude contour is also shown on the map which indicates the locations of the eastern and south-western ARP localities. Refer to Table 1 for names of each locality.

RESULTS

African Rock Pipit song

ARP song comprises a two-syllable “*whee-preeuuu*” vocalization, repeated during a singing bout. Syllable 1 (S1) is a drawn-out whistle while syllable 2 (S2) is a more complex trill, consisting of up to 4 components with varying numbers of notes in each component. The duration of song phrases ($x = 1.34$ sec; $SD = 0.25$; range = 0.69 – 3.01; $n = 1470$) and intervals between song phrases ($x = 5.43$ sec; $SD = 1.64$; range = 2.02–17.64; $n = 1263$) varied considerably between individuals. Mean recorded song bout duration was 7.8 minutes ($SD = 5.36$; range = 2.2–22.0; $n = 19$) with 5.3 – 10.6 ($x = 8.4$; $n = 19$) song phrases per minute. A male recorded at Thaba Nchu (site 13, Fig. 1) on 17 January 2006 called continuously for 30 minutes, of which 22 minutes were recorded.

Male ARPs typically sing while perched on an elevated

rock, assuming an upright posture during intense singing, with the bill pointing skywards and held wide open. In this posture the white chin of the bird is clearly visible. Individuals sing from large boulders and usually lift their tails (like scrub-robins *Cercotrichas* spp.) while singing. During a song bout, the pipit usually turns its head between successive songs.

Song variations

ARP song can be classified into three variations, based on differences in syllable 2 (S2): (1) S2 comprised mainly of a trill at a constant frequency (1 to 4 sub-types); (2) S2 has a trill with a progressively descending frequency (more notes in S2b of sub-type 2); and (3) S2 starts with a descending trill, followed by a trill at a constant frequency (Fig. 2). S1 may sometimes be repeated softly, before the pipit continues with the full song.

Variations 1 and 2 were most frequently recorded in ARP singing bouts. Only variation 1 was used for PCA statistical

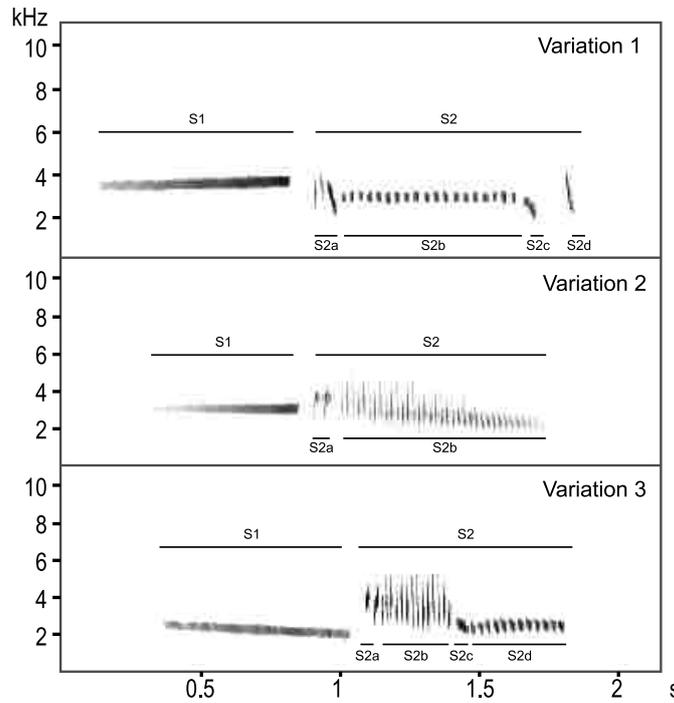


Fig. 2. African Rock Pipit *Anthus crenatus* song variations based on differences in syllable 2 of song.

analysis, since this variation was present in all study populations. The number of notes in S2b in variation 1 varied from 5–26 notes ($\bar{x} = 13$; $n = 1074$), while that in S2b of variation 2 ranged from 22–56 notes ($\bar{x} = 38.7$; $n = 360$). The duration of S2b in variation 2 was significantly longer (0.884 seconds) than in variation 1 (0.571 seconds) ($t = 37.85$; $df = 1432$; $P < 0.05$). S2b of variation 3 is of a shorter duration and has a constant frequency (8–26 notes), and S2d ends with notes similar to S2b of variation 1. Variation 3 was occasionally recorded during the song bout where variations 1 and 2 were the main vocalization (example from Vaalkop, Petrusburg on 13 July 2006).

Individual and inter-population variation

Sonograms of song phrases from different localities also indicate considerable variation in the structure of the song

phrase components. Principal component analyses (PCA) indicate significant differences in S2a and S2b between different localities. The songs were divided into two main groups (south western below 1500 m.s.l.) and eastern (above 1500 m.s.l.) populations). The Eigen values of the correction matrix were 37.18%, 27.30% and 16.26% for PC1, PC2 and PC3 respectively (Fig. 3).

Variations in S2a and S2b

The number of component notes and the frequency ranges of these notes in S2a and S2b vary significantly between localities. There is also some variation between individual birds at the same site with regard to these parameters (mainly S2a and S2b) (Table 1).

Similarities in song from localities close to each other were evident between the Hagesdam, Vlakfontein and Vaalkop sites.

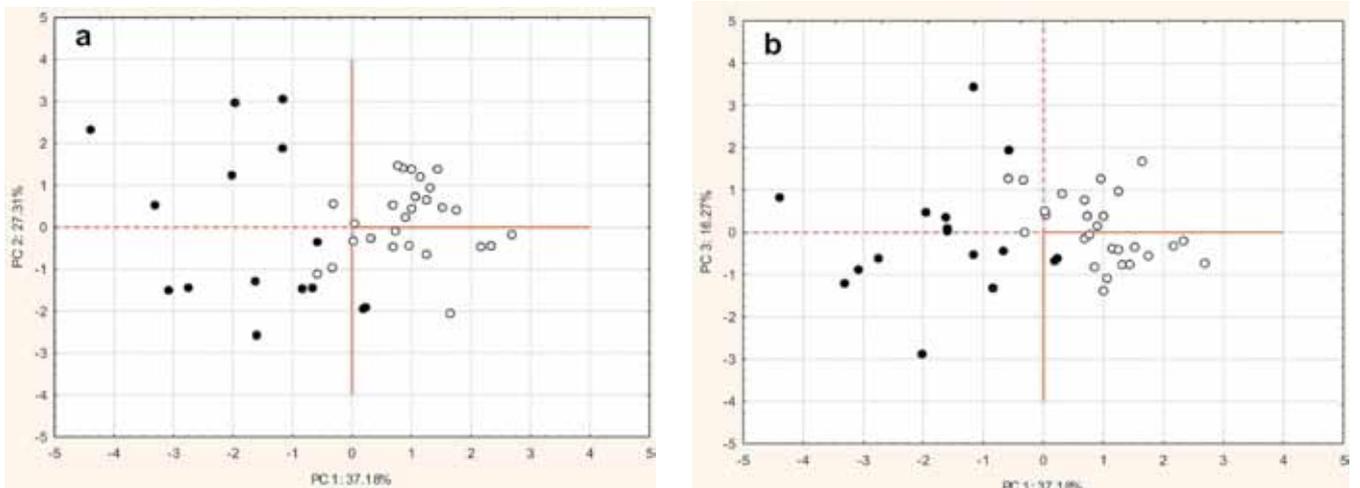


Fig. 3. Principal Component Analysis (PCA) of African Rock Pipit *Anthus crenatus* vocalizations. Significant differences between the south-western (indicated by black dots) and eastern populations (indicated by open circles) of the Free State, Lesotho and the Eastern Cape are evident. The Eigen values of the correction matrix for PC 1 and PC 2 were 37.18% and 27.31% in **a** and for PC 1 and PC 3 37.18% and 16.27% in **b**.

The number of S2a (2–5) notes from song variation 1 from Hagesdam was similar to Vaalkop and Vlakfontein sites, but the number of notes and duration of S2b (15–26) and S2a differs significantly between these localities (S2a duration: $F_{6,86} = 111.42$, $P < 0.05$; S2b notes: $F_{6,86} = 91.88$, $P < 0.05$; S2b duration: $F_{6,86} = 14.76$, $P < 0.05$). One song recording from Hagesdam has a similar single note S2d (in a few song phrases) to the Vlakfontein song. The song recordings from Driekop, Philippolis, Springfontein and the Tussen-die-Riviere Nature Reserve (TDR) localities, which are approximately 30–40 kilometers apart, differ significantly (ANOVA: all-significant at $P < 0.05$).

At Driekop, Philippolis, recordings were made from 4 different singing male ARP in territories spaced between 700 m and 2000 m apart. The songs of the males were individually distinct, differing significantly in the duration and frequency

ranges of the notes in S2a ($F_{3,89} = 522.69$, $P < 0.05$). The Driekop 1 recording has 8 notes in S2a (the first 5 notes at a lower frequency than the last 3), the Driekop 2 recording contains 5 notes (the first 3 at lower frequency than the last 2), while Driekop 3 has 6 notes (4 notes at a lower frequency to the last 2). Driekop 2 was similar to Driekop 4, although the durations of S2a and S2b were significantly different (S2a duration: $F_{1,25} = 37.45$, $P < 0.05$; S2b duration: $F_{1,25} = 152.98$, $P < 0.05$) (Fig. 4). The notes of S2b of syllable 2 are similar but differ significantly in number and duration between the different individuals, (S2b duration: $F_{3,89} = 201.87$, $P < 0.05$; S2b notes: $F_{3,89} = 497.18$, $P < 0.05$).

At Springfontein three ARP songs were recorded from Gannahoek and another two across the plains on the mountain slope of Groot Suurfontein (7 km away). The songs differ significantly between these two sites in the song phrase

Table 1. African Rock Pipit *Anthus crenatus* song characteristics from the Eastern Cape, Free State and Lesotho. Refer to Fig. 1 for locations of the site numbers. Song recordings from Koffiekuil (site 5), Bleskop (site 6) and Lesotho 3 (site 20) vary only in respect of syllable 2b and are excluded from the analysis.

Site	Locality	Notes S2a	S2a duration	S2a frequency range	Notes S2b	S2b duration	S2b frequency
1	Kloofeind01				18	0.568	0.72
1	Kloofeind02				13	0.470	1.32
1	Kloofeind03	1	0.040	1.10	18	0.510	0.71
2	Hagesdam01	4	0.110	2.06	19	0.566	0.67
2	Hagesdam02	2	0.074	1.55	19	0.566	0.67
3	Tafelkop	2	0.072	1.84	17	0.537	0.63
4	Vlakfontein	2	0.042	0.68	23	0.584	0.87
7	Nuwerus	2	0.081	0.59	6	0.324	0.74
8	Driekop01	8	0.180	1.36	15	0.606	1.33
8	Driekop02	5	0.107	1.40	12	0.516	0.89
8	Driekop03	6	0.142	1.37	10	0.461	1.01
8	Driekop04	5	0.107	1.31	10	0.467	0.92
9	Gannahoek01	5	0.089	1.74	21	0.742	0.80
9	Gannahoek07	5	0.091	1.45	17	0.623	0.70
9	Gannahoek08	5	0.088	1.49	18	0.675	0.67
9	Grootsuurfontein02	3	0.152	2.02	11	0.481	1.03
9	Grootsuurfontein05				6	0.400	1.43
10	TDR01	5	0.121	1.12	18	0.730	0.50
10	TDR02				14	0.534	0.47
10	TDR04	8	0.168	1.09	19	0.743	0.48
10	TDR05	5	0.111	0.95	11	0.426	0.60
10	TDR06a	6	0.134	1.10	10	0.394	0.54
10	TDR06b	6	0.133	1.14	14	0.557	0.50
10	TDR07	10	0.222	0.88	18	0.697	0.56
11	Kramberg01	1	0.030	0.87	11	0.577	1.56
11	Kramberg02	8	0.354	0.60	8	0.458	1.32
11	Kramberg03	1	0.034	0.83	11	0.589	1.60
12	Tierkoek01	12	0.232	1.55	17	0.780	1.59
12	Tierkoek02	18	0.334	1.72	16	0.727	1.60
13	Thaba Nchu	20	0.435	1.84	9	0.388	0.85
14	Bethlehem				6	0.672	2.43
15	Harrismith01	1	0.048	1.56	5	0.456	2.50
15	Harrismith02	1	0.048	1.55	5	0.450	2.55
16	Geluksdal				6	0.528	1.91
17	Fouriesburg				6	0.717	2.57
18	Lesotho01	1	0.046	1.33	7	0.764	1.61
19	Lesotho02	2	0.075	1.35	6	0.637	1.34
21	Lesotho05	11	0.628	2.10	9	0.760	2.11
21	Lesotho06	7	0.366	1.37	10	0.932	2.27
22	Lesotho07	11	0.398	1.77	11	1.040	2.67

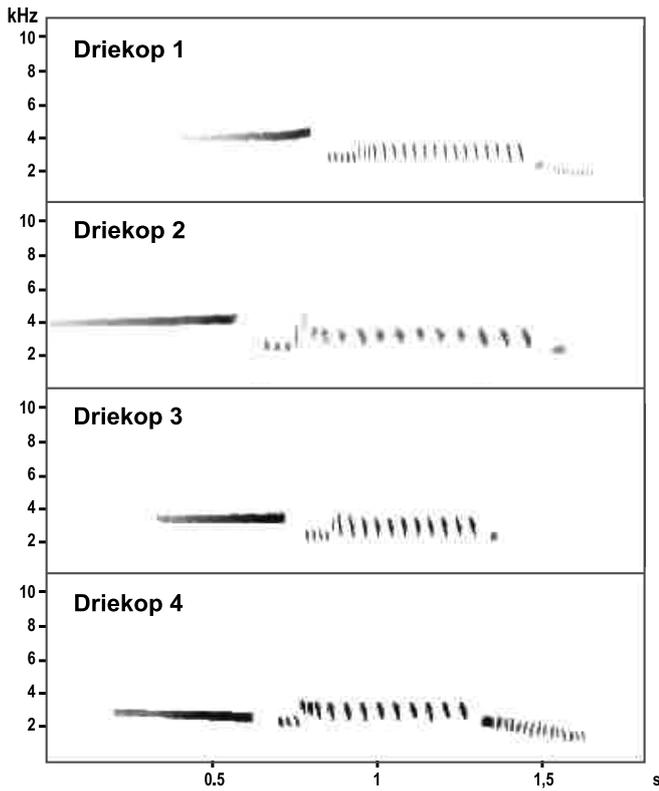


Fig. 4. African Rock Pipit *Anthus crenatus* sonograms recorded from four territories at Driekop, Philippolis from 3–5 October 2006.

duration and the number of notes in S2b (S2a absent in one recording) (song phrase duration: $F_{5,209} = 88.54, P < 0.05$; S2b notes: $F_{5,209} = 504.0, P < 0.05$) (Fig. 5). At TDR, five different singing ARP males were located in an area of roughly 230 ha between 300 m and 2200 m apart. All these individuals (TDR1, 2, 5 & 6) share a similar sparrow-like S2c component (2–3 notes) in their songs, and the song phrases differ significantly in S2a duration, and in number and duration of S2b notes (S2a duration: $F_{3,91} = 145.17, P < 0.05$; S2b duration: $F_{4,109} = 766.68, P < 0.05$; S2b notes: $F_{4,109} = 1273.18, P < 0.05$) (Fig. 5). Also at TDR, but approximately 10 kilometers across the plains, the songs of TDR4 & 7 was found to differ significantly from the above-mentioned recordings (S2a duration: $F_{5,117} = 96.85, P < 0.05$; S2b duration: $F_{6,135} = 618.80, P < 0.05$).

ARP songs at higher altitudes in the eastern Free State at De Villiersdrift (Fouriesburg), Geluksdal (Verkykerskop), Houtkop (Bethlehem) and Mount Everest Nature Reserve (Harrismith) were also individually distinctive (Fig. 6). The song phrase durations, S2b durations and number of component notes in S2b differed significantly (song phrase duration: $F_{4,155} = 55.41, P < 0.05$; S2b duration: $F_{4,155} = 180.94, P < 0.05$; notes S2b: $F_{4,155} = 110.34, P < 0.05$), but the duration and number of notes in S2a were not significantly different (mostly 1–3 notes or absent). The notes in S2b also have a wider frequency range (1.88–2.43 kHz) than these notes in phrases of south-western populations.

The songs recorded from the Lesotho Highlands were rela-

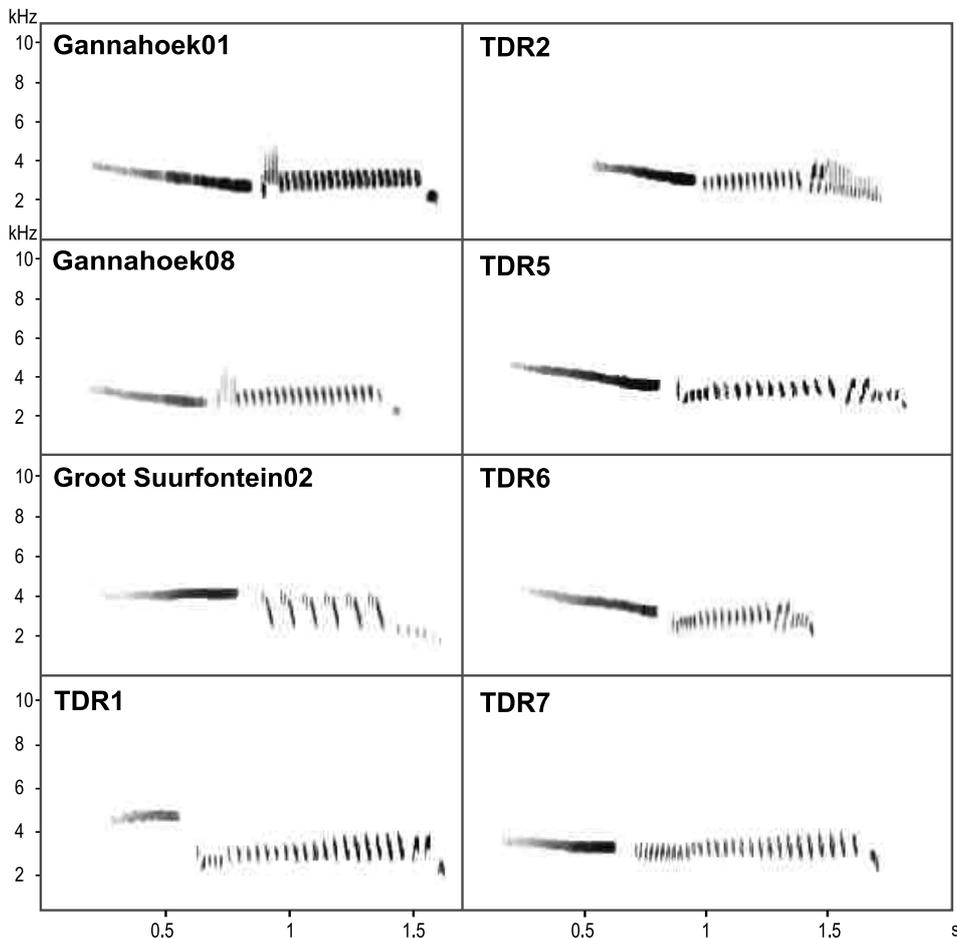


Fig. 5. African Rock Pipit *Anthus crenatus* sonograms recorded from Springfontein from 25–28 October 2004 and Tussen-die-Riviere-Nature Reserve (TDR), Free State from 17–19 October 2006.

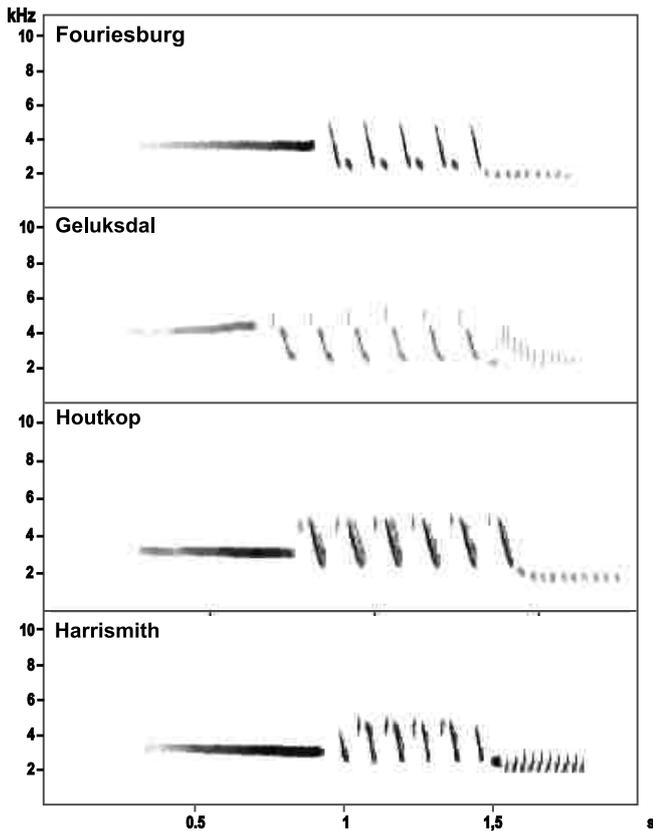


Fig. 6. African Rock Pipit *Anthus crenatus* sonograms recorded from the eastern Free State localities at Fouriesburg (29 November 2007), Houtkop, Bethlehem (10 October 2005), Harrismith (17–18 October 2007) and Geluksdal, Warden (30 November 2004).

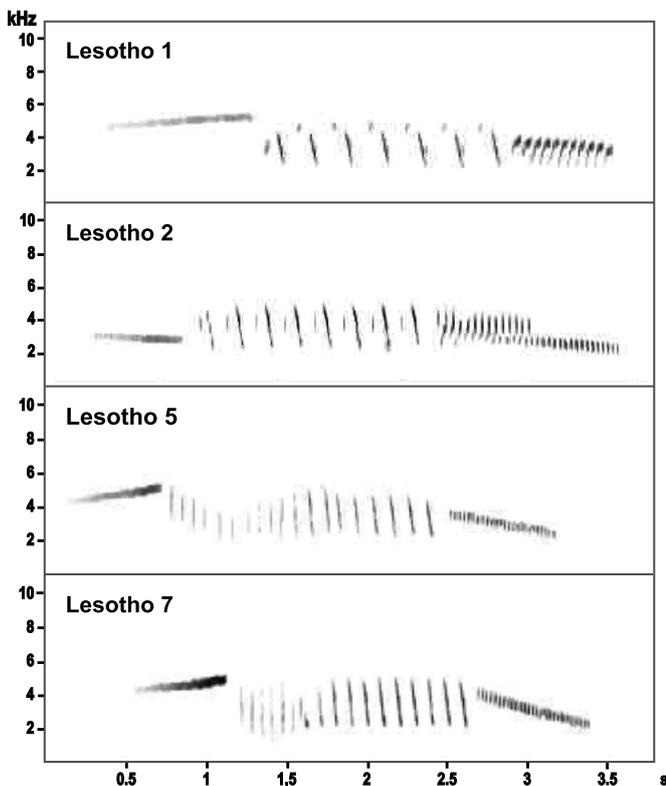


Fig. 7. African Rock Pipit *Anthus crenatus* sonograms recorded from the Rhamabantha (Lesotho 1), Semongkong (Lesotho 2) and Mohale Dam areas (Lesotho 5–7) in Lesotho from 6–9 November 2007.

tively similar to those from the eastern Free State, but differ individually (Fig. 7). The songs from the Rhamabantha (Lesotho 1), Semongkong (Lesotho 2) and Mohale Dam (Lesotho 5–7) were individually distinctive, differing significantly in the duration of song variation 1 and 2 (Song variation 1: $F_{3,32} = 235,82$; $P < 0.05$; song variation 2: $F_{5,168} = 106,16$; $P < 0.05$), S2a duration (Song variation 1: $F_{3,32} = 1091,34$; $P < 0.05$) and S2b duration (Song variation 1: $F_{3,32} = 6,674$; $P < 0.05$; song variation 2: $F_{5,168} = 106,16$; $P < 0.05$). Discriminant function analysis (DFA) groups the Rhamabantha (Lesotho 1) and Semongkong (Lesotho 2) vocalizations together, while Mohale Dam (Lesotho 5–7) vocalizations as three distinctive populations (Fig. 8). The DFA Wilks' Lambda statistics on the seven vocal characters were significantly different ($F_{28, 80} = 158.24$; $P < 0.05$).

DISCUSSION

This is the first detailed study of African Rock Pipit vocalizations. The three variations in the song phrases of this species have not previously been described in detail, although song variation 2 (the “*whee-tsreee*” or “*wheeu-prreeu*” phrase) was described by Keith *et al.* (1992), Voelker (2005), and also illustrated in Maclean (1993). The results of this study indicate that much variation occurs in ARP song, especially in the number and positioning of the component notes of S2a and S2b, both between individuals and different populations of this species. The PCA results group the data from southwestern and eastern localities into two distinctive groups. The extent of song variation in other areas of ARP distribution range is still unexplored and merits further study. This study also represents the first known investigation of individual and inter-population song variations in African Anthus (Peacock 2006, Voelker 2005). Osiejuk *et al.* (2007) studied the song structure of Tawny Pipits *A. campestris* in Poland and identified up to 20 song types. Tawny Pipit vocalizations were also found to be individually distinctive and invariant, which suggests that the different song types are important in individual recognition (Osiejuk *et al.* 2007).

Individual and inter-population variations (often termed dialects) in bird song have been studied in several species such as the White-crowned Sparrows *Zonotricha leucophrys* (Cunningham *et al.* 1987, Nelson 2000, Nelson & Soha 2004), Black-capped Chickadee *Poecile atricapillus* (Gammon *et al.* 2005, Kroodsema *et al.* 1999) and the Carolina Chickadee *Parus carolinensis* (Ward 1966). Such dialects can be defined when the songs within one population share certain structural characteristics which are different from other nearby populations (Catchpole 1985). This study on ARPs clearly illustrates the occurrence of individual and inter-population variations in vocalizations of this species. The topography between the Driekop, Springfontein and TDR localities is mostly hilly with undulating plains between the hills, these isolated “islands” of preferred habitat could result in isolation and the development of such variation in ARP songs.

In most instances micro-geographical variation evolves mostly over short distances, and can clearly be illustrated in vocalizations of the White-crowned Sparrow which is the most studied example of the occurrence of song dialects in birds (Catchpole 1985, Baptista *et al.* 1982). Soha *et al.* (2004) found in his study on Puget Sound White-crowned Sparrows

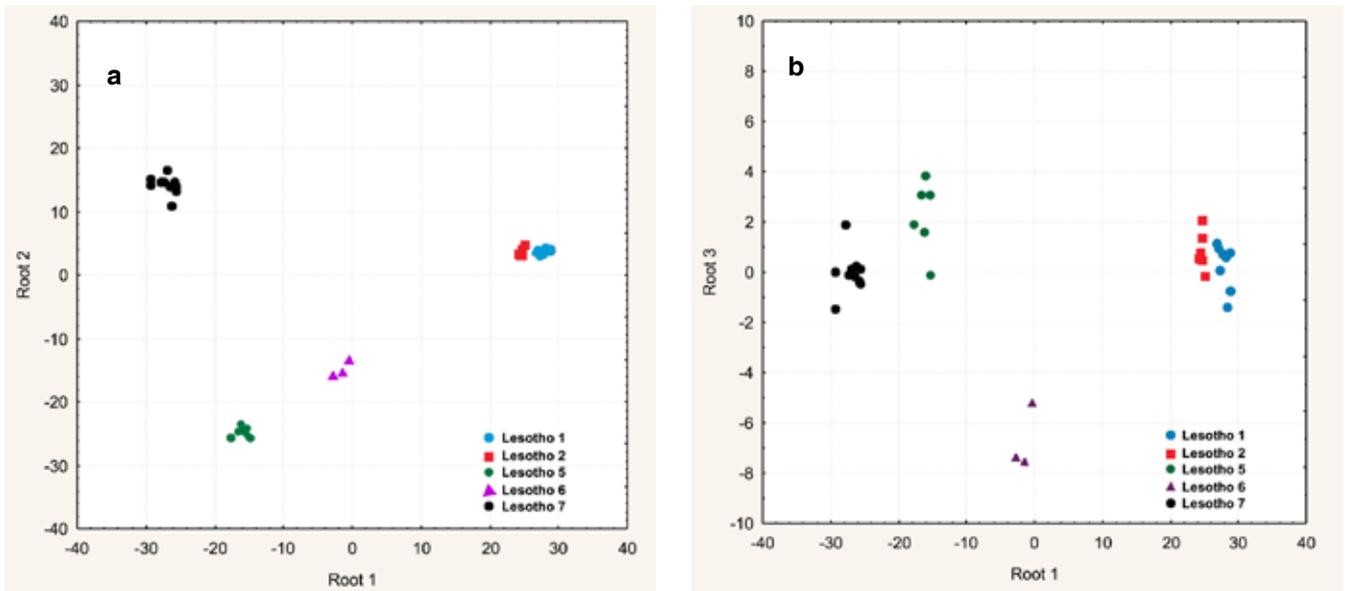


Fig. 8. Discriminant Function Analysis (DFA) on African Rock Pipit *Anthus crenatus* songograms from the Rhamabantha (Lesotho 1), Semongkong (Lesotho 2) and Mohale Dam areas (Lesotho 5–7) in Lesotho during November 2007. The DFA Wilks' Lambda statistics on the seven vocal characters were significantly different and are shown in **a** and **b** (see Results). Lesotho 1 is indicated by blue circle, Lesotho 2 by red square and Lesotho 5–7 by green circle, purple triangle and black dot respectively.

Z. leucophrys pugetensis that most song birds acquire particular songs through imitations of models produced by conspecifics, when the song is acquired in the same geographical area in which they establish breeding territories. In Black-capped Chickadees a particular whistle component of each song type possibly has its origin where birds on islands exhibit a greater structural diversity than mainland sites (Gammon *et al.* 2005).

In the south western Free State, ARP sites in isolated hilly areas such as Vlakkfontein, Driekop, Springfontein, Philippolis, and TDR are separated by large areas of unsuitable habitat (karoo or grassland plains) and songs differ both between individuals and between the populations (see results). Several song recordings from different ARP males at certain localities (such as Driekop, Springfontein and TDR) were similar in general song structure, but differed individually in the number of component notes and structure of S2a and S2b of syllable 2 in the song phrases. Such micro-geographical variation has also been observed within a small area where birds sing the same basic song (e.g. Leader *et al.* 2000).

Peacock (2006) highlighted an apparent gap in distribution of ARP in the Free State along the 27°E line of longitude that may suggest the development of a rift between the Karoo forms of ARP to the west and the grassland forms to the north and the east. A similar distribution gap also occurs between the Great and Klein Karoo (Clancey 1997, Peacock 2006). However, it needs to be confirmed that this gap in distribution is not merely attributable to lack of data for certain map squares. The recording sites at Driekop, Springfontein and TDR are separated by flat karoid vegetation while those further east (Thaba Nchu, Fouriesburg, Bethlehem, Harrismith and the Lesotho Highlands) are on higher altitude grasslands. The results of the PCA on song characteristics suggest a separation between these western karoo and eastern grassland forms. Future studies need to investigate the extent of the differences between these two populations along their entire distribution range, and also include the isolated populations in the Northern Cape (Voelker 2005).

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