

Taxonomic relationships of the subspecies of the Cape Parrot *Poicephalus robustus* (Gmelin)

J. O. WIRMINGHAUS†, C. T. DOWNS, M. R. PERRIN and
C. T. SYMES

*School of Botany and Zoology, University of Natal, Private Bag X01,
Scottsville, South Africa, 3209*

(Accepted 14 August 2000)

In Africa, four genera represent the family Psittacidae; of these, the genus *Poicephalus* Swainson is endemic and comprises nine species. Three subspecies of the Cape Parrot, *Poicephalus robustus* (Gmelin), are often recognized. The endangered nominate subspecies, *P. r. robustus*, inhabits afro-montane forest habitats and is endemic to South Africa. *Poicephalus r. suahelicus* (Reichenow) occurs in low-lying woodland in south-central Africa. The little-known third subspecies, *P. r. fuscicollis* (Kuhl), historically occurred from Angola through West Africa but is now common only in the Gambia where it occupies habitat similar to that of *P. r. suahelicus*. Validity of these subspecies has been examined using morphological and ecological characters. *Poicephalus r. suahelicus* and *P. r. fuscicollis* are most similar morphometrically and in plumage colour. The nominate subspecies and *P. r. suahelicus* showed several significant morphometric and colour differences, although local populations are parapatric in Mpumalanga Province, South Africa. Clancey's (1997) proposals are adopted with *P. robustus* considered a separate species from *P. fuscicollis* (with two subspecies *P. f. fuscicollis* and *P. f. suahelicus*).

KEYWORDS: *Poicephalus*, taxonomic status, afro-montane forest, conservation status.

Introduction

The species concept has been much debated and reviewed (Mayr, 1957; Lack, 1983; Brothers, 1985; Ridley, 1993), but criteria for recognizing taxa as subspecies include allopatric regional populations that differ in several traits. The presently recognized subspecies of *Poicephalus robustus* (Gmelin) share morphological similarities despite present disjunct distributions and different habitat preferences. Three subspecies of the Cape Parrot *P. robustus* are currently recognized (figure 1) (Forshaw, 1989). The nominate subspecies, *P. r. robustus* (Gmelin: no locality;

† Deceased

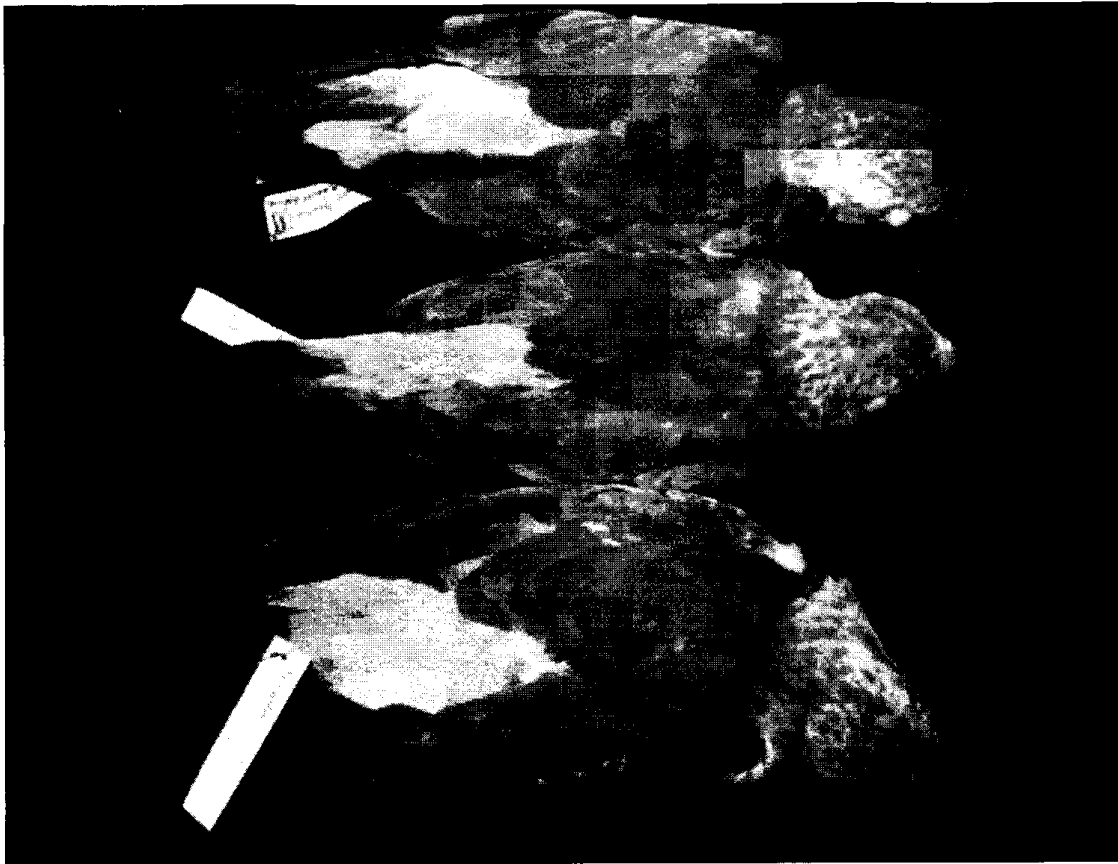


FIG. 1. The three previously recognized taxa of the Cape Parrot (top to bottom): *P. r. fuscicollis* (BM1929.2.8.111 from the Gambia); *P. r. suahelicus* (BM1890.10.10.48 from Zambezi River); and *P. r. robustus* (BM1890.10.10.39 from Natal).

though referred to as South Africa (Peters, 1937) or eastern Cape Province (Clancey, 1963)), is endangered (Downs 2000) (figure 2). *Poicephalus r. suahelicus* (Reichenow) occurs in south-central Africa (figure 2) where it is not regarded as threatened (Collar and Stuart, 1985), although trade in wild birds has increased, which could threaten remaining populations. A little-known, third subspecies, *P. r. fuscicollis* (Kuhl), historically occurred from Angola through West Africa, but is now only common in the Gambia (figure 2).

Disjunct distributions of flora and fauna have been extensively studied throughout Africa. Several species of trees of the afro-montane forests have a very disjunct distribution (Donald and Theron, 1983) which is explained by the climatic change hypothesis (Coetzee and van Zinderen Bakker, 1970; Donald and Theron, 1983). The distribution patterns of extant forest-dwelling birds in southern Africa are thought to be a consequence of vicariance events affecting forest plants following climatic changes (Hamilton, 1989; Lawes, 1990).

The great majority of disjunctions shown by montane birds probably originated as a consequence of fragmentation of continuous ranges (Moreau, 1966). Cluster analysis of the distribution patterns of forest passerine birds in tropical Africa has shown three main categories: those with restricted distribution, those with disjunct distribution, and those with wide distribution (Diamond and Hamilton, 1980). Centres of species richness, endemism, and disjunction coincide spatially, and are identified as forest refugia; forest persisted in these areas throughout the climatic

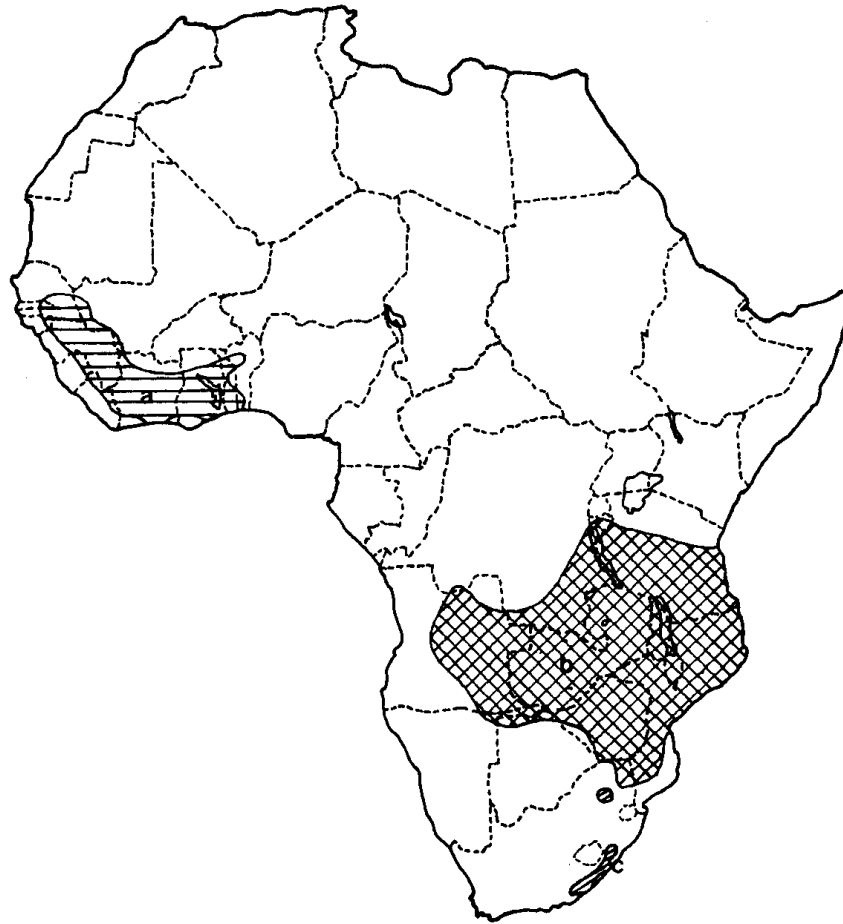


FIG. 2. Map of Africa with the distributions of the three previously recognized taxa: (a) *P. r. fuscicollis*; (b) *P. r. suahelicus*; and (c) *P. r. robustus* (after Forshaw 1989).

vicissitudes of the Quaternary (Diamond and Hamilton, 1980). The congruence of the disjunct avifaunal patterns with palaeoecological and geomorphological events support the forest refugia hypothesis (Crowe and Crowe, 1982).

Afromontane forest formerly extended over much greater areas of the sub-continent during interglacial periods but became fragmented and restricted during intervening drier periods (van Zinderen Bakker, 1969). The glacial maxima seriously affected the extent of evergreen forest in Africa, and many cases of disjunction shown by African forest organisms date back to the time of the last glacial maximum (Lawes, 1990). The present day range of *P. r. robustus* is confined to forests that were refugia during the last glacial maximum, i.e., afromontane forest patches in the Eastern Cape, KwaZulu-Natal and Mpumalanga (Lawes, 1990). Similarly, *P. r. fuscicollis* occurs in West African forest refugia created during the height of the glacial maximum. This suggests that separation and differentiation of these taxa occurred during the last glacial maximum. During the interglacial to preglacial period (100,000–18,000 BP) there was probably an extension of the *Poicephalus robustus* superspecies (including *P. r. fuscicollis*, *P. r. robustus*, *P. r. suahelicus* and *P. gulielmi* (Jardine)) across the entire range of miombo woodland and afromontane forest. At the glacial maximum (18,000 BP) separation appears to have occurred between sub-populations, with *P. r. robustus* confined to the southern afromontane areas and *P. r. suahelicus* to miombo woodland in the north. *Poicephalus r. suahelicus*

probably retained characters typical of the ancestral super-group including wide habitat tolerances, which enabled range extension during the post glacial. This radiation is supported by molecular analysis using RAPD data for the genus *Poicephalus* (Massa personal communication).

The Limpopo River Valley was an effective barrier during the Pleistocene interglacials and the ranges of several valid subspecies and species currently terminate at this arid river valley, including *P. r. robustus*, *P. cryptoxanthus* (Peters) and *P. meyeri* (Cretzschmar) (Clancey, 1994). Furthermore, the Limpopo River has marked altitudinal and ecological characteristics causing vicariance in the ranges of the birds breeding north and south of the river (Clancey, 1994). Clancey (1997) proposed that the Cape Parrot, *P. r. robustus*, be separated at the species level from the northern subspecies because of its restriction to the southern African afro-montane *Podocarpus* forest biome.

Because of the disjunct ecological distributions and variations in behavioural and plumage colour variations, the status of the *Poicephalus robustus* subspecies was examined using morphological and ecological parameters. Population numbers of *P. r. robustus* are low (Downs and Symes, 1998; Wirminghaus *et al.*, 1999), therefore recognition of its species status has major implications for its conservation.

Methods

One hundred and sixty-one specimens of *Poicephalus robustus* were examined: British Museum, Tring (54), Durban Natural History Museum (10), East London Museum (15), Transvaal Museum, Pretoria (34), Muséum National D'Histoire Naturelle, Paris (9), Field Museum of Natural History, Chicago, Illinois (4), National Museums of Kenya, Nairobi (2), Natural History Museum, Bulawayo (32) and one captive bird. A suite of 19 body measurements (table 1) and plumage colour codes, particularly for the head, body and tail (table 1), using a colour-formula guide (747 XR, Pantone Inc, USA), was recorded for each specimen. The plumage codes for the respective colours are presented in table 2. Morphological measurements taken were similar to those of Schodde *et al.* (1993) and included: wing (flattened chord), tail (base to apex of exposed retrices), tarsus (notch on heel to knuckle of longest toe forward) and length, width and depth of maxilla and mandible (figure 3). Morphological data were analysed using Principal Components Analysis (Statistica, Statsoft Inc., USA) as a reduction method to determine reliable characters and eliminate redundant characters. Differences among taxa for the accepted morphometric characters were examined separately for adult males and adult females, using multiple analysis of variance (MANOVA, Statistica, Statsoft Inc., USA). Further analyses of variance (ANOVA, Statistica, Statsoft Inc., USA) for each morphological character, were performed between taxa and between sexes. Juveniles (<9 months) were excluded from all analyses to avoid variation caused by development or size. Criteria for separating juveniles from adult birds were absence of red coloration on the wing and tarsus, bill size and museum tag information.

Results

Sixteen female and 25 male *P. r. robustus*, 27 female and 40 male *P. r. suahelicus*, and six female and 15 male *P. r. fuscicollis* were examined and their geographic ranges are shown in figure 4. The distribution of collection localities is similar in

Table 1 Morphometric and colour characters of *Poicephalus* taxa.

Character	Measurement
MH1	Interorbit, distance between anterior orbit ridges measured across brow
MH2	Jaw-hinge, outer distance across jaw-hinge
ML	Length, cere-base to tail-tip along head contour
MW	Left wing length
MTL	Tail length using inner rectrices
MT	Tarsus length
MB1	Culmen, (from edge of cere along curve to bill tip)
MB2	Culmen and cere, from cere-base along curve to bill tip
MB3	Maxilla greatest depth, measured close to cere from cutting edge to bill-ridge
MB4	Smile length, maxilla tip to cutting-edge/cere join
MB5	Maxilla tip length, from nook anterior tooth to bill-tip but measured parallel to outer face
MB6	Maxilla actual length, shortest length from edge of cere on bill-ridge to bill-tip (sagittal plane)
MB7	Maxilla breadth, greatest distance across maxilla
MB8	Maxilla breadth at tooth (palatal ridge when viewed from underneath)
MB9	Ridge width, outside distance across ridge of maxilla at cere
MB10	Maxilla ridge distinctiveness; 0 = ridge rounded, 1 = sides of ridge vertical
MB11	Mandible depth, greatest distance from posterior cutting-edge to base
MB12	Mandible length, from tip to base in sagittal plane
MB13	Mandible width, taken closest to cere at cutting edge
ASex	Assigned sex on basis of forecrown colour, morphology and tag
AAge	Assigned age on basis leg & shoulder colour, morphology and tag; 1 = Ad., 2 = sub-ad., 3 = juv.
CH1	Bill colour
CH2	Forecrown colour
CH2a	Forecrown colour code; 1 = orange, 2 = some feathers with orange, 3 = no orange
CH3	Crown colour
CH4	Collar and nape colour
CH5	Upper chest colour (part of 'hood')
CH6	Chin and throat colour
CH7	Cheek colour
CH8	Ear coverts colour
CH9	Lore colour
CB1	Mantle colour (area between wings) on wings
CW1	Colour around edge of scapulars
CW2	Colour around edge of upper wing coverts
CW3	Colour of flight and tail feathers
CW4	Shoulder edge colour
CW4a	Shoulder edge colour code; 1 = orange, 2 = some orange, 3 = no orange
CB2	Back colour
CB3	Rump colour
CB4	Colour of upper-tail coverts
CB5	Belly and lower chest colour
CB6	Colour of under-tail coverts
CB7	Flank colour
CL1	Colour of plumage on tibiotarsal tibiotarsus feathers
CL1a	Tibiotarsus colour code; 1 = orange, 2 = some orange, 3 = no orange
CY	Presence (1) or absence (2) of yellow feathers in plumage

Table 2. Colour codes used for plumage colour assessment of museum specimens of *Poicephalus* taxa following the colour formula guide (747 XR, Pantone Inc., USA).

Colour codes		
Group	Code	Colour
blacks	10	matt black
	11	dark slate
	12	grey
browns	20	slaty-brown
	21	silvery grey-brown
	22	rusty grey-brown
	23	warm rust-brown
	24	dark earth brown
	25	dark yellow-brown
	26	tan
reds	30	orange-brown
	31	pale orange-grey
	32	pinkish-brown
	33	pinkish-orange
	34	orange-red
	35	orange-green
yellows	40	dark yellow
	41	old ivory
	43	dark yellow-green
greens	50	blue-green
	51	leaf green
	52	dark green
	53	dark oily green
	54	olive (brownish)-green
	55	yellow-green
	56	grey-green
	57	pale blue-grey
	58	pale green
	59	medium green
	60	white/bleached ivory

figure 2, which shows a representative sample of the range of the recognized subspecies.

Plumage colour

Twenty-five colour characters were measured for the three taxa (table 1). Juvenile birds (<12 months) were removed from the analyses as plumage colour changes during development (Wirminghaus *et al.*, 2001). All juveniles had red on the forecrown but had no red on the tibia or leading edge of the wing. Bill size and body size differences were also evident.

The plumage colour characteristics that were consistently different between the sexes of adults of the three taxa were: crown, collar and nape, upper chest (part of the 'hood'), chin and throat, cheek and under-tail coverts (table 3). Crowns of *P. r. robustus* were greener than those of the greyer *P. r. fuscicollis* or the brown-grey-green *P. r. suahelicus*. Constant colour differences suggest recognition (of species) of the former from the latter two. Sexual dichromatism was evident in all three taxa with females being characterized by a bright pinkish orange (red) forehead whereas

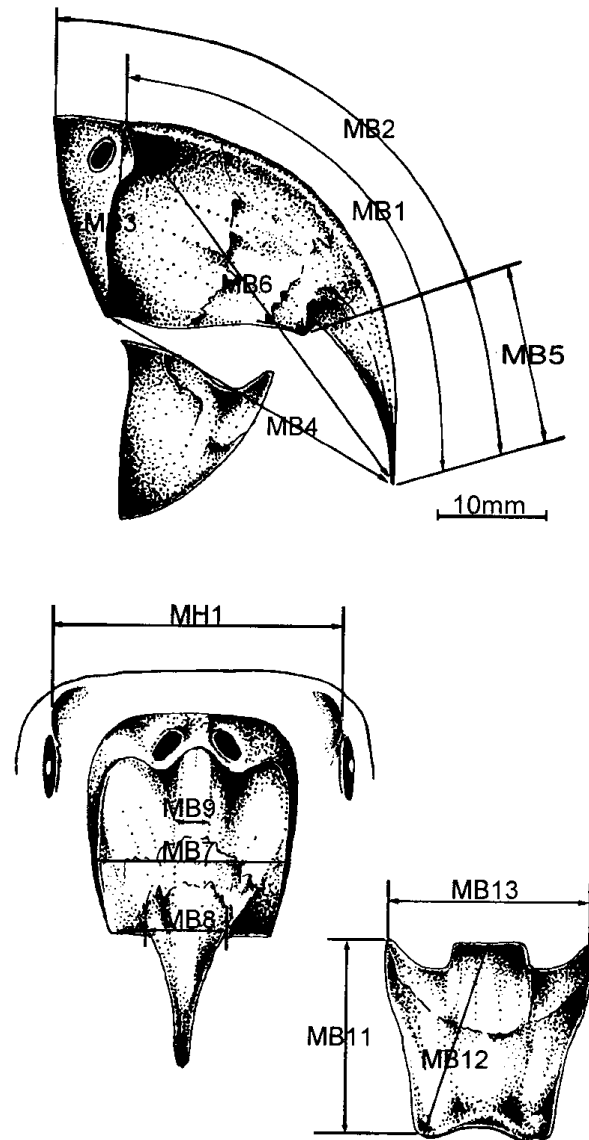


FIG. 3. Bill measurements obtained from the specimens measured.

males showed little or no red on the forehead (table 3). Presence of aberrant yellow plumage feathers is shown in table 4.

Juveniles of both sexes have an orange-red forehead in their first plumage, but only acquire red on the tibia and edge of the wing when they moult to adult plumage (Rowan, 1983; present study). In juveniles the colour is more salmon pink and extends further on to the crown than in adults. At 8–10 months this colour is replaced in males with an olive golden brown.

Morphometrics

Initially, the suite of morphometric characters measured for adult males was analysed using PCA with a minimum eigenvalue of 0.500, which resulted in five factor values (with percent of total variance in parentheses) as 11.51 (63.93%), 2.25 (12.53%), 1.31 (7.30%), 0.97 (5.36%), and 0.78 (4.36%) respectively. All bill measurements (12) were significantly correlated with factor 1. Left wing length (MW) and tail length using inner rectrices (MTL) were significantly correlated with factor 2.



FIG. 4. Localities of museum specimens measured to show their geographical distribution.

Factors 3–5 had only one significant variable each. The resulting distribution of morphological variables using factors 1 and 2 of adult males (all taxa pooled) is shown in figure 5. Similar PCA of adult females using a minimum eigenvalue of 0.500 resulted in six factor values with total variance (in parentheses) of 10.99 (60.88%), 2.12 (11.79%), 1.45 (8.08%), 0.93 (5.17%), 0.77 (4.29%) and 0.54 (2.98%) respectively. Most bill measurements (11) were significantly correlated with factor 1. Left wing length (MW) and tail length using inner rectrices (MTL) were significantly correlated with factor 2 and factor 3 respectively. Factors 2–5 had only one significant variable each. The resulting distribution of morphological variables of adult females (all taxa pooled) using factors 1 and 2 is shown (figure 5).

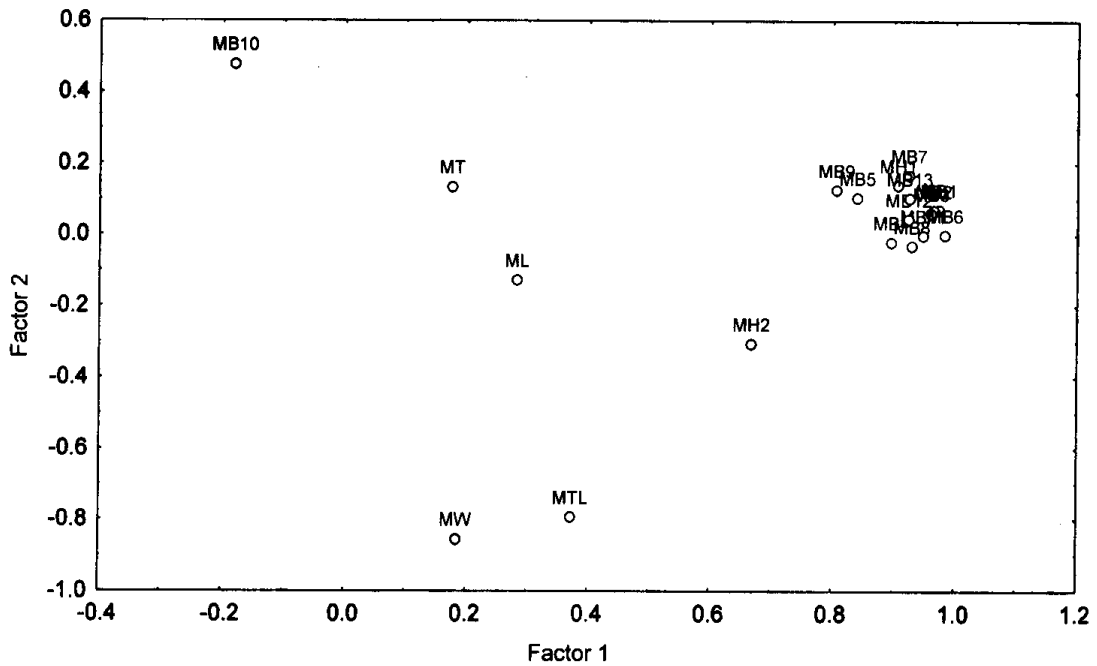
A general MANOVA of five morphological variables (MH2, ML, MW, MTL and MT) for adult males showed a significant difference between the three taxa of *P. robustus* (Wilks' lambda=0.4137*, Rao's $R=4.659^*$, $df=10, 84$, $p<0.05$). A significant difference between the three taxa was found using a general MANOVA of the 12 bill measurements for adult males (Wilks' lambda=0.1118*, Rao's $R=4.811^*$, $df=24, 58$, $p<0.05$). Scheffe tests showed that *P. r. robustus* and *P. r. suahelicus* were similar only in culmen breadth at tooth (MB8) and ridge width (MB9). However, *P. r. robustus* differed from *P. r. suahelicus* and *P. r. fuscicollis* in all other bill measurements, usually being smaller.

The three taxa differed significantly morphologically, (10 of 18 characters used

Table 3. Summary of median plumage colours of *Poicephalus* taxa.

Character	<i>P. r. robustus</i>		<i>P. f. sudanicus</i>		<i>P. f. fuscicollis</i>	
	male	female	male	female	male	female
CH1 Bill colour	41 old ivory	41 old ivory	41 old ivory	41 old ivory	41 old ivory	41 old ivory
CH2 Forecrown colour	24 dark earth brown	34 orange-red	22 rusty grey-brown	33 pinkish-orange	24 dark earth brown	33 pinkish-orange
CH3 Crown colour	54 olive-green	54 olive-green	22 rusty grey-brown	21 silvery grey-brown	22 rusty grey-brown	26 tan
CH4 Collar and nape colour	55 yellow green	55 yellow green	23 warm rust-brown	22 rusty grey-brown	56 grey-green	56 grey-green
CH5 Upper chest colour (part of 'hood')	55 yellow green	55 yellow green	22 rusty grey-brown	56 grey-green	22 rusty grey-brown	21.5 rusty grey-brown
CH6 Chin and throat colour	30 orange-brown	30 orange-brown	22 rusty grey-brown	23 warm rust-brown	22 rusty grey-brown	22 rusty grey-brown
CH7 Cheek colour	54 olive-green	55 yellow green	22 rusty grey-brown	23 warm rust-brown	22 rusty grey-brown	21.5 rusty grey-brown
CH8 Ear coverts colour	54 olive-green	55 yellow green	22 rusty grey-brown	22 rusty grey-brown	21 silvery grey-brown	21.5 rusty grey-brown
CH9 Lore colour	10 matt black	10 matt black	10 matt black	10 matt black	10 matt black	10 matt black
CB1 Mantle colour (area between wings)	53 dark oily-green	52 dark green	54 olive-green	54 olive-green	54 olive-green	54 olive green
CW1 Colour around edge of scapulars	53 dark oily-green	53 dark oily-green	52 dark green	52 orange-red	59 medium green	52 dark green
CW2 Colour around edge of upper wing coverts	53 dark oily-green	52 dark green	52 dark green	52 orange-red	59 medium green	56.5 pale blue-grey
CW3 Colour of flight and tail feathers	11 dark slate	11 dark slate	11 dark slate	11 dark slate	11 dark slate	11 dark slate
CW4 Shoulder edge colour	34 orange-red	34 orange-red	34 orange-red	34 orange-red	52 dark green	56 grey-green
CB2 Back colour	50 blue-green	50 blue-green	50 blue-green	50 blue-green	58 pale green	58 pale green
CB3 Rump colour	50 blue-green	50 blue-green	58 pale green	52 pale green	58 pale green	58 pale green
CB4 Colour of upper-tail coverts	50 blue-green	50 blue-green	58 pale green	50 blue-green	58 pale green	58 pale green
CB5 Belly and lower chest colour	50 blue-green	50 blue-green	51 leaf green	50 blue-green	54.5 yellow green	50 blue green
CB6 Colour of under-tail coverts	50 blue-green	50 blue-green	58 pale green	54 olive-green	54.5 yellow green	58 pale green
CB7 Flank colour	50 blue-green	50 blue-green	51 leaf green	50 blue-green	50.5 leaf green	58 pale green
CL1 Colour of plumage on tibiotarsal joint	34 orange-red	34 orange-red	34 orange-red	34 orange-red	34 orange-red	23 warm rust brown-orange red

a.



b.

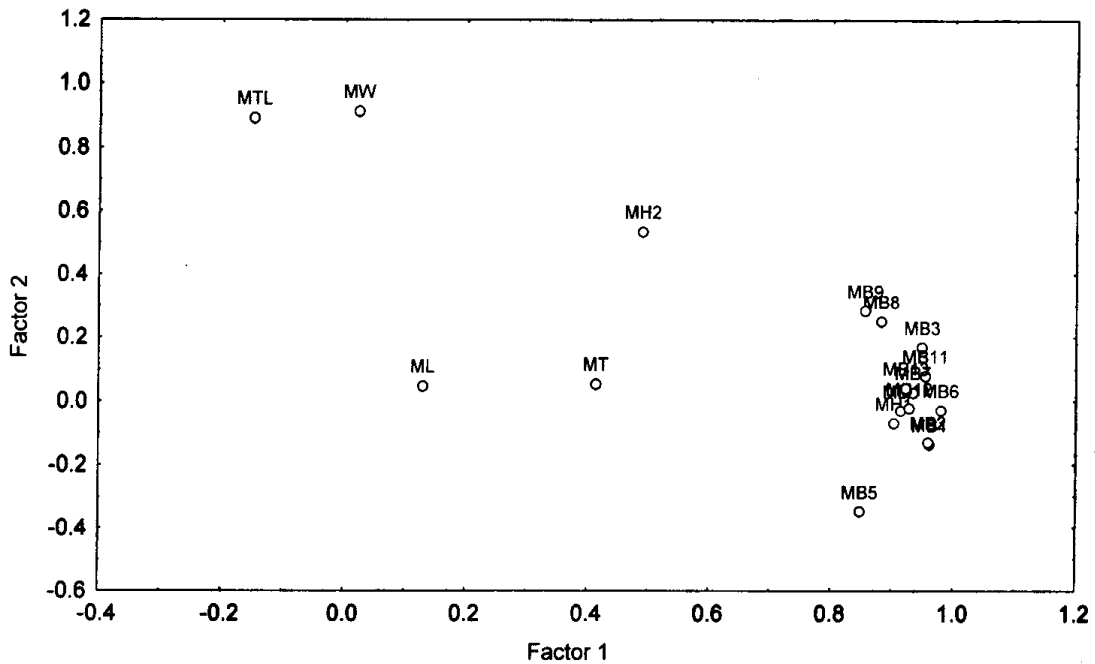


FIG. 5. Principal component analysis of the three previously recognized taxa where (a) includes adult males and females and (b) includes adult males only.

were significant, $p < 0.05$, ANOVA, table 5). Sexual dimorphism was very evident with males larger than females in stature and with a larger bill. *Poicephalus r. robustus* was the smallest of the three taxa (tables 5–6), particularly with its smaller bill dimensions. *Poicephalus r. suahelicus* and *P. r. fuscicollis* differed significantly morphologically (tables 5–6) although separation on plumage colours was more

Table 4 Presence of aberrant yellow plumage feathers in *Poicephalus* taxa

Subspecies	<i>n</i>	Yellow aberrant feathers present (%)	On scapula and wing coverts (%)	On body and head (%)
<i>P. r. robustus</i>	45	17.7	13.3	4.4
<i>P. r. suahelicus</i>	73	12.3	8.2	4.1
<i>P. r. fuscicollis</i>	21	19.0	14.3	4.8
Total	139	15.1	10.8	4.3

Table 5. Analysis of Variance results of morphological measurements of three *Poicephalus* taxa (marked effects are significant at $p < 0.05$).

Analysis of Variance Character	All taxa											
	All sexes				Females				Males			
	df Effect	df Error	<i>F</i>	<i>p</i>	df Effect	df Error	<i>F</i>	<i>p</i>	df Effect	df Error	<i>F</i>	<i>p</i>
MH1		92	18.64	0.00*	2	46	9.78	0.00*	2	77	21.16	0.00*
MH2		47	0.03	0.86	2	32	5.82	0.01	2	47	16.16	0.00*
ML		92	2.96	0.09	2	46	0.75	0.48	2	77	0.23	0.79
MW		91	0.14	0.71	2	43	0.53	0.59	2	76	2.72	0.07
MTL		92	1.93	0.17	2	46	1.32	0.28	2	77	0.58	0.56
MT		92	0.66	0.42	2	46	0.35	0.71	2	77	1.34	0.27
MB1		87	14.91	0.00*	2	43	35.87	0.00*	2	67	62.24	0.00*
MB2		87	10.07	0.00*	2	43	31.20	0.00*	2	67	57.31	0.00*
MB3		92	22.19	0.00*	2	46	27.62	0.00*	2	77	67.96	0.00*
MB4		87	8.33	0.00*	2	43	38.39	0.00*	2	67	40.07	0.00*
MB5		87	1.22	0.27	2	43	11.69	0.00*	2	67	14.03	0.00*
MB6		88	0.63	0.43	2	43	44.90	0.00*	2	68	55.38	0.00*
MB7		92	21.73	0.00*	2	46	27.75	0.00*	2	77	63.71	0.00*
MB8		92	24.76	0.00*	2	46	7.91	0.00*	2	77	13.02	0.00*
MB9		92	12.45	0.00*	2	46	2.22	0.12	2	77	2.60	0.08
MB11		92	9.20	0.00*	2	46	45.29	0.00*	2	77	104.22	0.00*
MB12		86	0.09	0.77	2	45	12.55	0.00*	2	73	24.74	0.00*
MB13		70	38.57	0.00*	2	30	14.35	0.00*	2	48	26.18	0.00*

difficult. Differences in body masses were not analysed as the data were incomplete. Body masses recorded for live Cape Parrots are summarized in table 7.

Discussion

Chapin (1939) described *P. r. robustus* as having a lower mandible <23 mm wide; the lighter, more greyish-headed *P. r. suahelicus* has a mandible 22.6–28.3 mm wide. Lower mandible width (<23 mm), together with other mandible and culmen measurements, was confirmed as a diagnostic feature for *P. r. robustus* in the present study. Davies (1907) described adult males of *P. r. robustus* from the Eastern Cape (Transkei) as being larger than females, with the hook at the end of the beak larger. The bill of *P. r. fuscicollis* has been described as larger and less yellowish (Chapin, 1939) than in *P. r. robustus*, which was supported by the present study. Bill differentiation is correlated with food preferences; however, it may also be used in phylogenetic studies (Darwin, 1899; Lack, 1983; Homberger, 1991, 1996). The Glossy Black-Cockatoo *Calyptorhynchus lathami* (Temminck) exhibits differentiation in bill size

Table 6. Morphological measurements of *Poicephalus* taxa.

Morphometric Characteristic	All		Males				Females					
	SE	<i>n</i>	\bar{x}	SE	<i>n</i>	Min	Max	\bar{x}	SE	<i>n</i>	Min	Max
MH1	0.15	45	30.6	0.2	25	29	33.3	29.6	0.2	16	28	30.9
MH2	0.28	43	36.3	0.3	23	32.7	39.1	34.4	0.5	16	31	37.6
ML	3.37	45	297.3	4.5	25	251	349	283.1	5.0	16	251	309
MW	0.93	42	218.3	1.1	24	210	231	210.5	1.0	14	205	219
MTL	0.63	45	94.8	0.5	25	90	98.9	89.3	1.1	16	79.6	97.2
MT	0.14	45	21.7	0.2	25	18.2	23.5	21.5	0.2	16	19.9	22.4
MB1	0.43	36	40.8	0.6	19	37	48	38.3	0.6	14	36	43
MB2	0.48	36	45.8	0.7	19	41	53	43.2	0.7	14	40	48
MB3	0.12	45	19.0	0.1	25	17.6	20.1	17.8	0.1	16	16.9	18.9
MB4	0.28	36	29.7	0.4	19	26.1	32.6	28.0	0.4	14	24.8	29.9
MB5	0.34	36	13.5	0.5	19	10.6	19.3	12.3	0.3	14	10.4	15.2
MB6	0.35	36	35.3	0.5	19	31.4	41.4	33.3	0.4	14	30.2	36.1
MB7	0.13	45	20.7	0.2	25	19	22.5	19.7	0.2	16	18.5	21
MB8	0.13	45	11.7	0.2	25	10.4	15	11.2	0.1	16	10.6	12.1
MB9	0.08	45	5.4	0.1	25	4.1	6.7	4.9	0.1	16	4.3	5.7
MB11	0.15	45	19.2	0.1	25	18.2	20.8	18.0	0.2	16	16.3	20.5
MB12	0.19	45	21.9	0.2	25	19.6	24.8	20.6	0.3	16	18.6	22.5
MB13	0.29	15	21.8	0.4	7	19.8	23	20.9	0.3	8	19.4	21.9

(A) *P. r. robustus*

Table 6. (Continued).

Morphometric Characteristic	All			Males			Females				
	\bar{x}	SE	n	\bar{x}	SE	n	\bar{x}	SE	n	Min	Max
MH1	31.7	0.2	73	32.1	0.2	40	28.5	0.2	27	28	33.7
MH2	38.5	0.5	33	40.0	0.4	16	37	0.6	15	29.6	38.8
ML	290.7	2.7	73	294.0	3.8	40	217	4.6	27	247	343
MW	219.6	1.8	73	222.0	1.9	40	199	4.0	27	196	315
MTL	93.8	0.7	73	95.1	0.8	40	77	1.2	27	82.8	107
MT	22.1	0.1	73	22.2	0.2	40	19.2	0.2	27	18.5	24
MB1	45.7	0.3	70	46.9	0.4	38	42	0.5	26	38	49
MB2	51.7	0.4	70	53.0	0.4	38	47	0.6	26	44	55
MB3	20.4	0.1	73	20.9	0.1	40	18.9	0.2	27	16.4	22.3
MB4	32.8	0.2	70	33.7	0.3	38	30	0.3	26	27.6	34.5
MB5	15.9	0.3	70	16.5	0.4	38	11.3	0.5	26	10.3	19.9
MB6	40.6	0.9	70	40.7	0.3	38	37.7	0.4	26	33.6	43
MB7	22.2	0.1	73	22.6	0.1	40	20.8	0.2	27	19.6	23.6
MB8	12.1	0.1	73	12.3	0.2	40	9.8	0.2	27	10.1	13.9
MB9	4.9	0.1	73	5.1	0.1	40	3.4	0.1	27	3.6	6.2
MB11	21.8	0.2	73	22.4	0.2	40	18.6	0.2	27	16.8	23.8
MB12	24.0	0.3	69	25.1	0.3	37	21.9	0.3	27	20.1	26.9
MB13	23.2	0.2	52	23.5	0.2	29	21	0.3	19	21.1	26.1

(B) *P. r. suahelicus*

Table 6. (Continued).

Morphometric Characteristic	All			Males			Females				
	\bar{x}	SE	n	SE	n	Max	\bar{x}	SE	n	Min	Max
MH1	32.4	0.3	21	32.8	15	29.4	31.5	0.4	6	30.6	32.9
MH2	38.1	0.7	15	38.4	11	33.2	37.5	0.6	4	35.8	38.3
ML	293.5	5.7	21	292.3	15	224	296.5	9.6	6	260	320
MW	215.0	2.7	20	214.9	15	187	215.2	5.7	5	201	227
MTL	93.3	1.1	21	93.6	15	82.8	92.5	1.5	6	88	97
MT	21.9	0.2	21	22.0	15	19.1	21.7	0.5	6	19.7	22.8
MB1	49.1	0.8	19	50.6	13	44	45.8	0.9	6	43	48
MB2	54.2	0.8	19	55.4	13	49	51.7	0.6	6	49	53
MB3	21.4	0.2	21	21.9	15	20.3	20.3	0.3	6	19.1	21.2
MB4	34.0	0.4	19	34.0	13	31.3	33.8	0.9	6	31	37.5
MB5	16.5	0.4	19	17.2	13	14	15.0	0.7	6	12.4	16.7
MB6	41.4	0.6	20	42.0	14	35.6	39.8	0.7	6	36.8	41.4
MB7	23.4	0.2	21	23.8	15	22	22.4	0.5	6	21.4	24.6
MB8	13.5	0.3	21	13.7	15	11.4	13.1	0.5	6	10.8	14
MB9	5.5	0.1	21	5.5	15	4.4	5.2	0.2	6	4.6	5.9
MB11	22.7	0.2	21	23.0	15	21.6	21.9	0.2	6	21	22.8
MB12	24.4	0.4	19	24.6	14	21.8	23.7	0.4	5	22.8	25
MB13	25.5	0.4	21	26.1	15	22.2	24.1	0.4	6	23.2	25.2

(C) *P. r. fuscicollis*.

Table 7. Body masses (g) of *P. r. robustus* and *P. r. suahelicus*.

	Male	Reference	Female	Reference
<i>P. r. robustus</i>	295	Rowan, 1983	295	Present study, wild, juvenile
	285	Present study, captive	327.5	Present study, captive
	315.1	Present study, captive	260	Present study, captive
	328.5	Present study, wild		Present study, wild
<i>P. r. suahelicus</i>	326	Rowan, 1983	320.7	Rowan, 1983

among geographical subspecies (Schodde *et al.*, 1993). Relationships of three core groups and two outlier groups of Glossy Black-Cockatoo *Calyptorhynchus lathami* separated according to the first two principal components determined by canonical variate analysis of nine morphological variables recorded in males (Schodde *et al.*, 1993). Similar separation appears to have occurred in the *Poicephalus robustus* group.

Poicephalus r. robustus, the smallest of the three taxa examined (and an afro-montane forest-specific species), differed noticeably in appearance from the other two taxa. It has very specific nesting and habitat requirements (Wirringhaus *et al.*, 1999). *Poicephalus r. suahelicus* and *P. r. fuscicollis* differed significantly morphologically although they cannot be easily separated on plumage colours. Furthermore, they have similar habitat requirements (Rowan, 1983). Differences may have been caused by genetic drift of the smaller West African population, or by adaptation to a different habitat.

Clancey (1997) distinguished the two southern subspecies *P. r. suahelicus* and *P. r. robustus* by their head and neck coloration, body plumage colour and the size of the bill, which is supported by the present study. The bill of *P. r. suahelicus* is heavier basally than in *P. r. robustus* and the apex is longer and more tapered to a point, while culmen length measured from the cere is longer (Clancey, 1997; present study). Clancey (1997) proposed *P. robustus* be accepted as a separate species on morphological, biogeographical and ecological differences, but revised the arrangement of *P. fuscicollis*; with two subspecies *P. f. fuscicollis* and *P. f. suahelicus*, which is also supported morphometrically by the present study. The different taxa are therefore referred by these names from here on.

Plumage colouring of the adult male of *P. robustus* was described as olive-yellow by Rowan (1983). Head and neck plumage colouring of *P. f. suahelicus* was described as silvery grey (Rowan, 1983). Forshaw (1989) described the plumage colouration of *P. robustus* as less variable and seldom with a bluish tinge compared with the other two subspecies. These colourings are similar to those of the present analysis (table 3). The hood of *P. f. suahelicus* tends to extend further down the throat and on to the breast than in *P. f. fuscicollis*. Furthermore, the grey colour of the head is whiter in the former than the latter, where it is washed variable brown, tending to an earth brown colour from the top of the head (crown), down the nape and on to the mantle. The wing coverts are generally edged lighter green in *P. f. fuscicollis* than in *P. f. suahelicus*. Variation between sexes and within each sex makes separation of these two subspecies difficult using plumage characteristics.

There is unusual sexual plumage dichromatism in the three *Poicephalus* taxa, with females having orange-red foreheads. Adult female *Poicephalus robustus* have varied forecrown plumage patterns, with some having orange across the forehead and others having none; none of the males had this forehead coloration (Davies, 1907; Skead,

1971; present study). Similarly, adult females of the northern two subspecies have the forehead and fore-crown bright red, whereas in males these are silvery grey merely tinged with red (Chapin, 1939; present study). In the latter subspecies this characteristic appears consistent (Chapin, 1939). *Poicephalus flavifrons* (Rüppell), the Yellow-faced Parrot, *P. gulielmi*, Jardine's Parrot, and *P. senegalus* (Linné), the Senegal Parrot all show similar sexual dichromatism (Bricknell, 1987; Forshaw, 1989).

Juveniles of both sexes in all three taxa have orange-red colour on the forehead in their first plumage, but only have red on the tibia or on the edge of the wing when they moult to adult plumage (Rowan, 1983; present study). The colour is more salmon pink and extends further on the crown in juveniles than in adults. At 8–10 months this colour is replaced in males with colour corresponding to the hood plumage colour (pers. obs.). During this moult the forehead may gain a yellow tinge (pers. obs.). This sexual dichromatism may act to reduce male aggression and facilitate parental care in a species that has a closed nest, where both sexes participating in parental care, and where a male solicits a female (Wirminghaus *et al.*, 2001).

Aberrant yellow feathers were found in several of the museum specimens and have also been observed in wild birds (pers. obs.). Such aberrations are feathers which lack the black pigment melanin (Alderton, 1992). They are typically a single yellow feather in the wing coverts, flight (remiges) or tail (rectrices) feathers, and more rarely as yellow patches on the body or head. Davies (1907) found that some of the brightest-coloured females also had one or two bright yellow feathers amongst the median wing coverts, a yellow feather on one wing and none on the other, suggesting it was a further sexual dimorphic characteristic. However, in this study, both sexes were found to have these yellow feathers. Furthermore, distribution and frequency of these aberrant feathers showed that they were not a sexually dimorphic character. Aberrant feathers are more common in some local populations than others (pers. obs.) suggesting a genetic relationship. They are useful for identifying individuals in the wild, but may cause confusion and misidentification when identifying other *Poicephalus* parrots with overlapping distributions (Wirminghaus, 1995).

In conclusion, the behavioural evidence (Rowan, 1983), distribution data, specific habitat requirements (Skead, 1964; Wirminghaus *et al.*, 1999) and morphological differences presented here support that the southern taxon *P. r. robustus* is a separate species from the northern subspecies *P. r. suahelicus* and *P. r. fuscicollis*. Consequently Clancey's (1997) proposals are adopted with *P. robustus* as a separate species from *P. fuscicollis* (with two subspecies *P. f. fuscicollis* and *P. f. suahelicus*). As population numbers of *P. robustus* are low (Downs and Symes, 1998; Wirminghaus *et al.*, 1999), recognition of its species status has major implications for its conservation.

Acknowledgements

The staff of the Transvaal Museum, Pretoria; Durban Natural History Museum; the East London Museum; the British Museum, Tring; the Natural History Museum, Paris; Field Museum of Natural History, Chicago, Illinois; National Museums of Kenya, Nairobi; Bulawayo Natural History Museum; and W. Horsfield are thanked for their assistance with providing specimens. We are grateful to Dr P. Clancey for discussions. Bradford Howe and Jenny Buck kindly assisted with figures.

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