Bird Conservation International (2012) 22:184–192. © BirdLife International, 2011
doi:10.1017/S0959270911000335

Re-assessment of the conservation status of Malawi's 'Endangered' Yellow-throated Apalis *Apalis flavigularis*

TIWONGE I. MZUMARA, PHILIP A. R. HOCKEY and AMANDA R. RIDLEY

Summary

The forest-associated Yellow-throated Apalis *Apalis flavigularis* is the only bird endemic to Malawi. The species is confined to three mountain massifs in the south of the country and is classified as globally 'Endangered'. This study re-evaluates its conservation status by assessing its population size and habitat preferences on Mount Mulanje, where forest patches are threatened by illegal logging and an increasing frequency of uncontrolled fires. These fires also cause a proliferation of invasive plant species, especially the Himalayan yellow raspberry *Rubus ellipticus*. We surveyed the Yellow-throated Apalis in 41 forest patches during the breeding season. The apalises favoured forest edge habitat, occurring in forest patches as small as 0.01 ha. Their occurrence was positively correlated with the presence of *R. ellipticus*, although this relationship may be driven primarily by canopy architecture and the existence of an understorey shrub layer. At a conservative estimate, 7,900 Yellow-throated Apalises were calculated to be present in cedar forest habitat alone on Mount Mulanje. Given that the birds occurred in other native forests at the same altitude at densities of 8.6–10.9 birds ha^{-1}, the true population size on Mount Mulanje alone is likely to approach or even exceed IUCN's most optimistic estimate of the global population (10,000).

Introduction

The Yellow-throated Apalis *Apalis flavigularis* is a small, forest-associated passerine endemic to three mountain massifs in southern Malawi - Malosa, Zomba and Mulanje. Within these massifs, where the species is estimated to occupy a total range of 510 km^2, its habitat has been, and continues to be, severely fragmented by forest exploitation (BirdLife International 2010). This threat, coupled with the small estimated population size (2,500–10,000 individuals, and decreasing), has resulted in its classification as globally 'Endangered' (BirdLife International 2010). Among the proposed action plans for the Yellow-throated Apalis is improved protection of the remaining forest habitat (BirdLife International 2010). However, monitoring the success of such action is compromised by a lack of knowledge of the species' basic biology, habitat preferences and true population size.

Mount Mulanje (15°50′–16°03′S, 35°30′–35°47′E) was selected as the study site because of its status as a Biosphere Reserve (UNESCO 2000) and the likelihood that in future it will be the best conserved of southern Malawi's massifs and thus will be the key to preserving the biodiversity of these massifs. Aside from being one of only three massifs where Yellow-throated Apalises occur, Mulanje supports more than 50 endemic plant species (Strugnell 2002) and 10 endemic reptiles (Dudley 2004).

The vegetation of the Mulanje Plateau comprises mostly remnant forest patches in a grassland matrix (Chapman 1961, 1962, Dowsett-Lemaire 1988). The forests differ from those of other massifs in southern Malawi by virtue of the presence of the endemic Mulanje cedar *Widdringtonia whytei*, an emergent tree that can reach 40 m at maturity (Chapman and White 1970). Forest remnants occur in ravines, depressions, and along streams, with the higher parts of the Plateau (> 2,500 m)

https://doi.org/10.1017/S0959270911000335 Published online by Cambridge University Press

being much less forested than the lower slopes. Three invasive plants are present in the forests, two alien (Mexican pine *Pinus patula* and Himalayan yellow raspberry *Rubus ellipticus*) and one native species (bracken *Pteridium aquilinum*; Bayliss *et al.* 2007).

Human pressures have impacted both vegetation and wildlife on the mountain (Edwards 1985). The current rate at which the cedar is being removed could drive it to extinction within a decade (Bayliss *et al.* 2007). The government forestry department alone is unable to address the various threats on the mountain and a conservation organization, the Mulanje Mountain Conservation Trust, has been established to help to conserve the mountain's biodiversity.

Given the anthropogenic threats to Mount Mulanje and the dearth of basic biological information about the Yellow-throated Apalis, the aims of this study were 1) to quantify the habitat preferences of the species, especially in relation to patterns of forest degradation; 2) estimate the size of the Mount Mulanje sub-population; and 3) assess whether the current IUCN threat category of 'Endangered' is appropriate.

Study Area and Methods

Study area

Mount Mulanje is an isolated, granite massif in south-eastern Malawi (Strugnell 2002). It covers an area of 650 km^2 and rises to 3,002 m (Bayliss *et al.* 2007). The woodland habitat of the drier northern, eastern and western slopes is dominated by *Brachystegia* (miombo; Dudley 2004). The southern and south-eastern lower slopes (600–900 m) support lowland forests which form part of the Guineo-Congolian region of endemism (Chapman and White 1970). From 900 to 1,500 m, the slopes support transitional, mid-altitude forests (Dowsett-Lemaire 1989). Above the mid-altitude forests are submontane forests: these generally lack emergent trees. Afromontane forests are confined, with few exceptions, to ravines and hollows on the plateau below the cliffs and in gorges from 1,850 to 2,300 m (Chapman, 1994). Mulanje cedar dominates many of these forests as an emergent. Cedar forests occupy 845.3 ha of the massif (S. D. Makungwa unpubl. data).

Alien plants dominate in two places. In the north-western sector of the Plateau (Chambe) there is an extensive *Pinus patula* plantation, established in the mid-20th Century, probably replacing cedar forests (Chapman 1962). *Rubus ellipticus* was first reported in the 1930s (Chapman 1994). The shrub is now present in most areas on the plateau, with the most severe infestations at Chambe (Fig. 1).

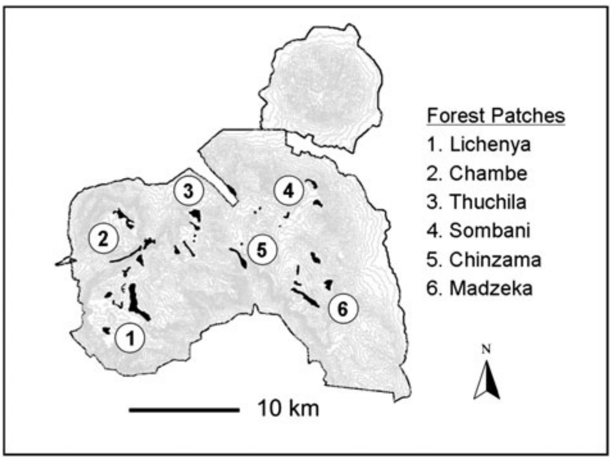

Figure 1. Map of Mount Mulanje Plateau showing the distribution of cedar forests (in black) in the six areas sampled.

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Methods

Surveys were conducted in the Afromontane and submontane forest patches of Mount Mulanje in October and November 2008, during the birds' breeding season (Dowsett-Lemaire and Dowsett 2006). Six areas on the massif above 1,500 m, (the lower limit of the species' range during the breeding season; Dowsett-Lemaire and Dowsett 2006) were surveyed: Chambe, Sombani, Lichenya, Madzeka, Thuchila and Chinzama (Fig. 1).

Forty-one forest patches were surveyed (24 containing cedar, 17 lacking cedar), ranging in size from 0.01 ha to 39.9 ha. In addition, two sites at Sombani cleared of pine in 2004 were sampled, as were two sites at Chambe cleared of pine in 2007. Surveys were also conducted in two extant pine stands at Chambe. For each patch, GPS location, elevation, size and matrix type (whether the patch was surrounded by grassland or scrub) were recorded.

Because the forest habitat is dense, bird densities were quantified using point counts positioned along transects (Sutherland *et al.* 2004). Whenever possible, natural paths were used as transects, but in some patches heavily invaded with *Rubus* it was necessary to cut paths through the vegetation.

Points were set at 50 m intervals along transects. At the time of the study, wild fires in the grassland matrix had spread to the very edges of most of the forest patches, leaving them without true ecotones. For this reason, the first sampling point on each transect was positioned 10 m into the patch, allowing for the forest edge to be included. Where patches were too small to accommodate a 50 m transect, the sampling points were positioned at the centres of the patches. At each sampling point, the song of the male Yellow-throated Apalis was played for 15 seconds and all birds seen or heard within a 20 m radius in a 5-minute period after the playback were recorded. Bird density (D, birds ha^{-1}) in each patch was calculated using the distance sampling formula for fixed-radius point counts ($D = n/k\pi w^2$; Buckland *et al.* 2008), where k is the number of plots in the design, n is the number of birds counted (summed across the k points), and w is the fixed radius of the plots (20 m). Estimation of total population size was problematic, because only the extent of forest patches containing cedars has been quantified: the total area of other montane forest patches is unknown (S. D. Makungwa *in litt.*). For each area, average apalis density was calculated for all the forest patches containing cedar. This was then multiplied by the total area of cedar forest in that area. In order that population estimates for cedar patches should be conservative, only data from patches larger than 5 ha were used in this estimate because in at least some smaller patches, territories extended into the scrub fringing the forest, which could lead to an over-estimation of apalis abundance per unit area of 'true' forest. However, other analyses relating apalis density to habitat characteristics included all patches. It is also possible that having sampling points only 50 m apart could result in 'double counting', such that birds attracted to playback at one sampling point would also be attracted to playback at an adjacent sampling point. In an attempt to obviate this potential bias, we also calculated densities using only data from sampling points 100 m apart (in the 14 patches large enough to do this). It is also possible that birds were attracted into the 20 m count radius from further away: this potential bias is more difficult to correct, and is particularly serious should it lead to an over-estimation of population density. The only means we have of testing this is using ringing data. In 2008, ringing was carried out during the breeding season in October and November in a 0.5 ha forest patch where (simultaneous) point-count data indicated that there should be a density of 6.4 apalises ha^{-1}: in other words, this patch should have contained three birds. Eleven different birds were trapped in the forest patch (eight within a period of only three days), suggesting that even when using playback, we were unlikely to have overestimated apalis abundance. It is possible that many of the 'extra' birds caught in mist nets were non-territorial floaters that may not have responded to playback, although such a high proportion of floaters (73%) seems intuitively unlikely.

To link apalis density to habitat features, a 20 x 20 m quadrat was established at each point where playback was used. In each quadrat, the height, bole height (height to the first branch) and crown diameter for all trees with a diameter at breast height (DBH) $\geq$ 50 mm were measured (Bibby *et al.* 1998).

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Canopy cover was estimated by looking through a 20 mm diameter tube at 10 randomly selected points within the plot and recording whether or not the sky was obscured. Two observers independently estimated shrub cover as a percentage of ground cover.

Standard statistics were generated using STATISTICA 8 (StatSoft Inc. Tulsa, USA). GenStat 11 (Genstat 11th edn, Lawes Agricultural Trust, Rothamstead, UK) was used for all mixed modelling. To determine how habitat characteristics affect apalis presence, we used a Generalized Linear Mixed Model (GLMM) with presence (1) or absence (0) of apalises at each point count as the response variable, using a binomial distribution with a logit link function. We tested the following variables as possible predictors of the presence of apalises: elevation; patch size; tree density; canopy cover; shrub cover; average bole height and DBH; and presence/absence of cedar, pine, *Rubus* and edge habitat. The identity of each forest patch was incorporated as a random term to account for the effect of repeated measures. Terms affecting apalis density within forest patches were analysed using a General Linear Model (GLM) with a normal distribution and identity link function. The response variable (apalis density) was log-transformed to achieve normality. Initially, all possible explanatory variables were included in the model. For both analyses, variables that showed the least significance were removed from the model sequentially, retaining only the terms whose exclusion significantly reduced the model's explanatory power (Crawley 2002). Among the vegetation variables, tree density and shrub height were the only ones that were not auto-correlated and both could therefore be included in the model, but their inclusion did not significantly improve the model fit.

Results

One hundred and sixteen apalises were counted at 95 sampling points in 41 forest patches totalling 192.68 ha in extent. In native forest patches, the average density of apalises (both males and females) was 12.78 birds ha^{-1} at forest edges and 9.85 birds ha^{-1} away from edges, but this difference was not significant (P = 0.615). Overall, apalis densities were highest in patches containing cedars (Table 1), but this difference also was not significant (GLM, P = 0.138).

Bird density and patch size were not significantly related, but the highest apalis densities occurred in six patches of $<$ 1 ha. One pair was resident in a forest patch of only 0.01 ha that was far from any large forest patch (and to which it would have been impossible to attract birds using playback).

No apalises were present in any pine stands sampled, nor were there any apalises in the regenerating scrub vegetation at Sombani, where pines were removed in 2004. However, birds were present at seven of the nine points where small numbers of pines were interspersed among native forest: pines were most widespread in forests lacking cedar (Table 1).

Table 1. Summary of attributes of Afromontane forest patches with and without cedar trees surveyed on Mount Mulanje.

Forest and bird attributes	With cedar	Lacking cedar
Number of forest patches	24	17
Sizes of forest patches (ha)	0.1–32.1	0.01–39.9
Altitude (m)	1775–2166	1759–2166
Average apalis density (birds ha^{-1})	9.35*	10.93**(8.62***)
Number of transect point counts	55	40
Proportion of points including forest edge	0.52	0.60
Proportion of patches with *Pinus patula*	0.08	0.23
Proportion of patches with *Rubus ellipticus*	0.38	0.47

*Based on the most conservative population estimate (see Results).

**Based on sample points at 50 m intervals.

***Corrected for the ratio of 'conservative estimate/estimate' based on 50 m interval samples from the patches containing cedars.

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The presence of Yellow-throated Apalis in a forest patch was best predicted by the presence of *Rubus ellipticus* (Table 2), i.e. those forest patches containing *Rubus* were the ones most likely to contain apalises. In the presence of *Rubus*, average apalis density did not differ significantly between forest patches with and without cedars. However, in the absence of *Rubus*, apalis densities were significantly higher in patches containing the endemic cedar (ANOVA $F_{1,22} = 5.26$, $P = 0.03$).

Apalis population estimate

The total area of cedar forest on the Plateau is 845.3 ha (S. D. Makungwa, unpubl. data). The average density of apalises in cedar patches across the six study areas was 10.5–12.3 birds ha^{-1} for sample points at 100 m and 50 m distance respectively (Table 3). This translates into an estimated population size of 10,450–10,680 individuals (Table 3). With the exception of one area (Lichenya), population estimates based on samples taken at 100 m intervals were equal to or smaller than those based on 50 m sample intervals. This is likely to be a consequence of the ranges of forest patch sizes on which the two estimates are based. The smaller estimate (10.5 birds ha^{-1}) is based on large patches, whereas the larger estimate (12.3 birds ha^{-1}) is based on both large and small patches: it is the smaller patches with the larger edge-to-core ratios that support the higher densities of birds. The exception was at Lichenya (where there was only one patch large enough to be sampled at 100 m intervals): here, the more 'conservative' technique yielded the highest population estimate. Inspection of the raw data indicated that (for reasons unknown) there was an uneven dispersion of apalises within this patch.

A more conservative estimate of the overall population in cedar patches can be obtained by summing the minimum population estimates for each area. This gives an estimated population of 7,904 birds (an overall average of 9.35 apalises ha^{-1}). It must be noted that this figure does *not* include those birds present in forest patches lacking cedars (whose total area is unknown). However, the average density of apalises in forest patches lacking cedars was at least 8.62 birds ha^{-1} (Table 1). Thus, even if the area of such forest was as small as 200 ha (certainly a gross underestimate), this would add more than 1,700 birds to the Mulanje population estimate. If we also take into account that, in the one forest patch where ringing took place, more than three times as many birds were caught as were predicted to be present based on transect data, the population estimate in cedar forests alone of c.7,900 birds may be conservative.

Discussion

Overall, there was no significant difference between average apalis densities in forest patches with and without Mulanje cedar. However, in the absence of *Rubus*, cedar patches supported higher apalis densities. Cedar patches have a discontinuous canopy which promotes the development of an understorey of tree saplings, shrubs and shrubby herbs (Chapman and White 1970) that the Yellow-throated Apalis favours. Afromontane forest patches lacking cedar have a more uniform and closed canopy with a very variable understorey layer, which in many places is all but absent (Chapman and White 1970).

Table 2. GLMM of the terms influencing the presence of Yellow-throated Apalis in forest patches, based on 95 point counts from 41 forest patches. Patch identity is included as a random term.

Minimal Model				
Variable	Wald statistic	*P*	Effect	SE
Constant			0.60	0.27
Rubus presence	4.66	0.03	1.26	0.58
Tree density	2.95	0.08		
Shrub height	0.72	0.27		

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Table 3. Estimated numbers of Yellow-throated Apalis in forest patches containing cedars at the six study areas on Mount Mulanje. The two estimates of population size are derived from different sampling intervals (50 m vs 100 m), but results for population sizes obtained using both techniques are extrapolated to the total area of cedar forest in each of the six sampling areas.

Site	Extent of cedar forest (ha)	Based on sample points 50 m apart (n = 41 patches)		Based on sample points 100 m apart (n = 14 patches)	
		Average density (birds ha^{-1} ± S.E.)	Population estimate	Average density (birds ha^{-1} ± S.E.)	Population estimate
Chambe	133.5	21.87 ± 4.98	2,920	9.28 ± 3.51	1,239
Chinzama	60.1	12.92 ± 3.93	776	9.94 ± 1.99	598
Lichenya	256.1	13.92 ± 2.20	3,565	23.86 ± 7.95	6,111
Madzeka	163.4	7.15 ± 1.99	1,168	6.19 ± 0.88	1,011
Sombani	53.6	7.95 ± 2.27	426	7.95*	426
Thuchila	178.6	10.22 ± 6.08	1,825	5.97*	1,065
Total/Mean	845.3	12.34 ± 2.19	10,680	10.53 ± 2.74	10,450

*n = 1 patch, no S.E. estimate possible.

In other studies of forest birds, canopy architecture has been reported to affect bird abundance (e.g. Cintra *et al.* 2006). In this study however, canopy cover showed no significant relationship with bird presence or abundance ($P = 0.785$). Tree density and shrub height had some small, but non-significant effects (Table 2), but probably play some role in habitat choice by the apalis. Insectivorous birds, such as apalises, are often considered to be very selective in terms of combining attributes of trees, perch positions and foraging techniques (e.g. Cintra *et al.* 2006). However, of particular relevance to conservation of the Yellow-throated Apalis is that the birds are present in even the smallest of forest patches, including those to which they could not have been attracted by playback, implying a degree of tolerance to forest degradation.

It has been proposed that if Mount Mulanje is to be maintained in a near-pristine state, the invasive *Pinus patula* should be removed (Edwards 1982, Sakai 1989, Verboom 1992, Bayliss *et al.* 2007). The Mulanje Mountain Conservation Trust has acted on this advice and has begun eradicating *P. patula* stands (D. Nangoma pers. comm.). Pines have been eradicated at Sombani and eradication is ongoing at Chambe. Results of this study support the pine-clearance initiative: apalises do not occur in pine stands, although they do tolerate low densities of pines interspersed within Afromontane forest (Table 1). To date, however, pine removal has had no positive impact on apalis numbers because the returning vegetation is at too early a successional stage. Although Yellow-throated Apalis did favour forest patches with a shrubby understorey (mostly *Rubus*), as does Namuli Apalis *A. lynesi* (Ryan *et al.* 1999), clearly the existence of a tree canopy above this shrub layer is important. The complete absence of apalises from *P. patula* stands is most probably because these stands lack such an understorey, as is the case in most monoculture pine forests (Ginsberg 2006).

Rubus ellipticus is listed as one of the top 100 invasive species in the world (Lowe *et al.* 2000). It grows to c.6 m in height and produces yellow fruits attractive to and easily dispersed by birds and mammals (Edwards 1982). The dispersion of Yellow-throated Apalis across forest patches was strongly associated with the presence of *Rubus* (Table 1). Although this finding was unanticipated, it is explicable. Yellow-throated Apalis is a bird of evergreen scrub (Dowsett-Lemaire and Dowsett 2006), favouring forest edges over forest interiors (this study). *Rubus* is also concentrated in ecotonal habitats, penetrating primary forest only where there has been disturbance, such as logging, which opens up the canopy (Brown and Gurevitch 2004).

At this stage, it is impossible to distinguish whether the positive association between Yellow-throated Apalis and *Rubus* is cause and effect or nothing more than coincidence. Regardless, however, the important point is that there is no evidence that apalises are negatively impacted by *Rubus*. Although exotic species are not invariably harmful to biodiversity (Rosenzweig 2001,

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Slobodkin 2001), several studies have shown that invasion of native forests by exotic flora does have significant negative biodiversity effects (Wilcove *et al.* 1998, Fritts and Rodda 1998, Gurevitch and Padilla 2004). If *Rubus* does indeed confer ecological benefits to insectivorous Yellow-throated Apalises, this is probably through enhanced abundance of insects associated with its flowers and fruits.

Whether *Rubus* also provides significant benefit in terms of nest sites is equivocal. During this study, nests were not observed in *Rubus*, but rather in the native shrub *Helichrysum schimferi*. Nests have been recorded in *Rubus* on Mount Zomba (T. I. M. pers. obs.), however, where the forests have also suffered from extreme fires and logging and where *Rubus* invasion is even more extensive than at Mount Mulanje (U. Nthenda pers. comm.), perhaps forcing the birds to use this substratum for nest sites.

Conservation implications and recommendations

The densities of Yellow-throated Apalis in Mulanje forests are comparable with those reported for Namuli Apalis in Mozambique (Ryan *et al.* 1999). The Yellow-throated Apalis population occupying cedar forests alone on Mount Mulanje (conservatively estimated at 7,900 birds) is towards the upper end of the IUCN's highest estimate for the global population across all three massifs where the species occurs (2,500–10,000 birds). The total population size on Mount Mulanje is unquestionably larger than this because of the species' occurrence at comparable densities in native forests lacking cedars.

Given that Mulanje is one of three isolated sites at which the bird occurs, its conservation status is likely to be much less precarious than that of e.g. Namuli Apalis or Taita Apalis *A. fuscigularis*, each of which is confined to a single site (BirdLife International 2010). Not only is the population of Yellow-throated Apalis larger than previously thought, but it is clear that the birds are tolerant of quite severe habitat degradation, including forest fragmentation, logging and invasion by alien plants.

The current 'Endangered' status of Yellow-throated Apalis is based on its putative population size, restricted distribution and anthropogenic forest loss, especially on lower mountain slopes (BirdLife International 2010) where an unknown proportion of the population moves during the winter non-breeding season (Dowsett-Lemaire and Dowsett 2006). Evidence from the high-altitude breeding forests (larger than expected population and tolerance of disturbance) suggests that the current status of 'Endangered' might be overly pessimistic. Nevertheless, if large numbers of birds do use lower altitude forests in winter, and these forests are under more severe threat that the high-altitude forests, this could change the picture. At the moment, however, the healthy size of the population in its breeding area suggests the species is under no immediate threat.

Nonetheless, a survey of Yellow-throated Apalis in the lower altitude forests should be a priority: this may require a different survey methodology because a) birds are unlikely to be as responsive to playback outside the breeding season, and b) their distribution may be more clumped (with the abandonment of territoriality). As a final caveat, the optimism expressed here does have an underlying assumption that the other two populations of Yellow-throated Apalises are themselves reasonably healthy and that the Mulanje population is not the only one that is viable.

Recommendations have been made that all exotic organisms should be removed from Mount Mulanje (Bayliss *et al.* 2007). This need may be especially true as regards *Rubus*, which forms thickets so dense that in many places no or very few indigenous plant species can grow through it (Edwards 1982). Eradication on the massif will, however, have to be tackled with care because removal of monospecific *Rubus* stands from within forest patches could result in complete loss of the shrub understorey for long enough for Yellow-throated Apalis to abandon such areas, in the same way as they avoid pine plantations lacking an understorey.

In conclusion, the current population of Yellow-throated Apalis on Mount Mulanje alone approaches or exceeds the most optimistic global population estimate (BirdLife International 2010). These findings suggest that the species is resilient to global extinction, at least in the short to medium term.

https://doi.org/10.1017/S0959270911000335 Published online by Cambridge University Press

Acknowledgements

We thank the Tropical Biology Association (TBA) and the Graça Machel Scholarship fund for financial support to T. I. M. We also thank Robert Dowsett and Françoise Dowsett-Lemaire for assistance in the field. The Forestry Department of Mulanje Mountain Forest Reserve, the Mount Mulanje Conservation Trust and the Mountain Club of Malawi all provided logistical and field assistance. We thank Peter Jones for comments on an earlier manuscript. This contribution forms part of the 50^{th} Anniversary celebrations of the Percy FitzPatrick Institute in 2010.

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TIWONGE I. MZUMARA[†], PHILIP A. R. HOCKEY*, AMANDA R. RIDLEY[††]

Percy FitzPatrick Institute of African Ornithology, DST/NRF Centre of Excellence, University of Cape Town, Private Bag X3, Rondebosch, South Africa 7701.

[†]*Current address: P.O. Box 31277, Chichiri, Blantyre 3, Malawi.*

[††]*Current address: Department of Brains, Behaviour and Evolution, Macquarie University, Marsfield 2122, Sydney, NSW, Australia.*

[*]*Author for correspondence; e-mail: phil.hockey@uct.ac.za*

Received 18 December 2009; revision accepted 28 April 2011;
Published online 5 December 2011

https://doi.org/10.1017/S0959270911000335 Published online by Cambridge University Press