Aspects of the ecology and morphology of the protea seedeater, *Crithagra leucopterus*, a little-known Fynbos endemic

Alan T.K. Lee[1]* & Phoebe Barnard[1,2]

[1]*Climate Change Adaptation Division, South African National Biodiversity Institute, Private Bag X7, Claremont, 7735 South Africa*

[2]*Percy FitzPatrick Institute of African Ornithology, DST/NRF Centre of Excellence, University of Cape Town, Rondebosch, 7701 South Africa*

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The protea seedeater, *Crithagra leucopterus,* is one of six passerine birds endemic to the Fynbos Biome, South Africa. It is the least known of these, and there is very little information on breeding and habitat use. Through nest observations and a bird ringing scheme in the eastern sections of the Fynbos, we provide updated information on habitat use, breeding and population biometrics. We document changes in capture rates for a suite of birds in relation to a fire event and use of burnt and unburnt sites within Blue Hill Nature Reserve, South Africa. Protea seedeaters were recorded nesting in mature Fynbos, but feeding in recently burnt Fynbos on freshly released protea seeds, suggesting the species benefits from small-scale burns that create a landscape of mixed veld ages. Protea seedeaters weighed less and had shorter wings compared to those of the western Fynbos. Further habitat-use and life-history information on protea seedeaters is needed to help guide conservation management plans, especially in the light of changing fire regimes in the Fynbos.

Key words: protea canary, fynbos birds, fire ecology.

The protea seedeater, *Crithagra leucopterus,* is one of six passerine bird species restricted to the Cape Floristic Region (Fynbos Biome) of South Africa (Barnes 1998; BirdLife International 2013). Its preference for this habitat was noted from the first descriptions of Fynbos bird communities (Winterbottom 1968). It has been the focus of one study, which primarily documented the distribution and diet of the species (Milewski 1976, 1978). Apart from one other note on aspects of its occurrence (Fraser & Richardson 1989), and a small amount of capture–recapture work that concluded the species was robust to a controlled fire event (Fraser 1989), little is known about the basic biology of the species. Most recently, modelling exercises based on atlas data on the impacts of climate change have predicted range-contractions for this species in a drier and warmer future climate (Huntley & Barnard 2012).

The protea seedeater is reported for a smaller and more fragmented area in South African Bird Atlas Project data from 2007 to 2011 than from 1987 to 1997 (Lee & Barnard 2012). This suggests that this species may soon be one of conservation concern, and that further information on its biology is needed to inform conservation measures. However, this species is poorly described (Fraser 1997), and even biometric data in Dean (2005) are based on a small sample size.

Bird ringing is used to investigate many aspects of avifaunal life histories (Bub 2012). A small number of protea seedeaters have been ringed at Jonkershoek, Western Cape, with one ringed individual resighted after a fire event (Fraser 1989). Although fire is an important natural disturbance in Fynbos and many plant species depend on it, especially serotinous species for release of their seeds, the role of fire in the distribution of the protea seedeater has not been addressed.

Our aim was to examine aspects of the ecology and morphology of the protea seedeater through ringing and general observations, including pre- and post-fire. In addition, capture data is compared with other bird species caught.

As part of a wider study to identify endemic bird movement patterns in aseasonal Fynbos, ringing has been conducted since January 2011 on or around Blue Hill Nature Reserve (BHNR; 33.34°S, 23.26°E; Fig. 1), in the Kouga mountains, on the western border of the Baviaanskloof Nature Reserve, Western Cape, South Africa. BHNR lies between 1000 and 1530 m asl. Annual rainfall is 344 ± 102 mm and aseasonal: there is little difference between summer and winter monthly totals (average monthly rainfall Dec–May: 38 ± 30; Jun–Nov: 28 ± 28 mm). Further details of the

*Author for correspondence. E-mail: alan.tk.lee@googlemail.com

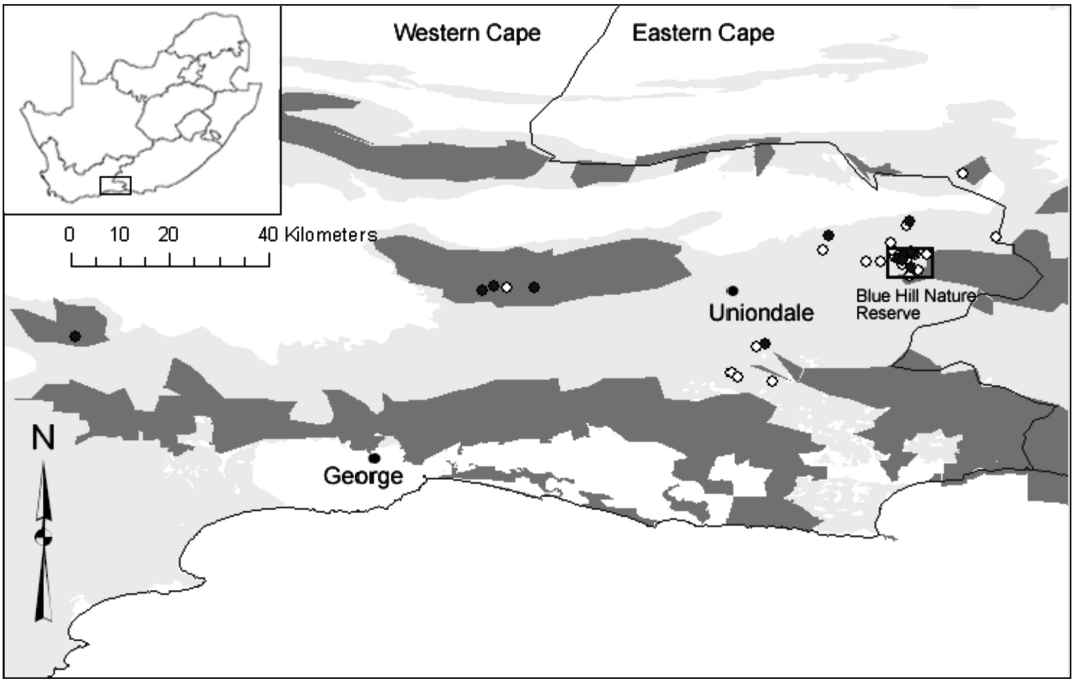

Fig. 1. Map of ringing locations in the Western Cape, South Africa. Sites where protea seedeaters were captured are displayed as black dots, while ringing sites with no captures are white dots. State-protected areas are shaded dark grey and the Fynbos biome is shaded light grey. The location of BHNR is outlined in black in the main map associated with the cluster of ringing sites.

vegetation, geology and climate are described in Lee & Barnard (2013). In January 2012 a widespread wild fire burnt large tracts of BHNR and surrounding areas (*c.* 10 000 ha).

From 27 July 2011 to 29 June 2013, A.T.K.L. spent 197 days ringing at 40 sites, 18 of which were at BHNR (Fig. 1). On BHNR, 53 days were spent ringing prior to the fire, 24 days in burnt areas after the fire, and 68 days in unburnt areas after the fire. No birds ringed outside the study area were recaptured during this period.

We present standardized capture rates (SCR) as an index of relative abundance. SCR are calculated as the number of birds caught per effort, where effort is number of metres of net multiplied by hours of operation, divided by 1000. We tested for differences in SCR for the sites pre-fire, post-fire burnt and post-fire unburnt sites using independent samples Kruskal-Wallis tests. Tarsus was measured to joint and wing length was recorded as length of maximum chord (as per De Beer *et al.* 2001). Independent sample *t*-tests were used to compare body mass and wing length of birds captured here (in aseasonal rainfall Fynbos) to those in the SAFRING database (from winter rainfall Fynbos).

We searched for nests and evidence of breeding on an opportunistic basis, mostly through undocumented wandering transects and direct observations of birds encountered in the field.

High SCR and encounter rates suggest that protea seedeater is fairly common in the Fynbos of the Kouga Mountains. Protea seedeaters were captured on 24 days, comprising 71 newly ringed birds and two recaptures (both within 1 km of their site of original capture). The rate of capturing protea seedeaters were higher in burnt areas compared to unburnt areas before and after the fire ($K = 10.05$, $P = 0.005$, d.f. = 2; Fig. 2), even though there was no difference for the group consisting of the other granivores (a group including Cape canary, *Serinus canicollis* (n = 4), Cape siskin, *Crithagra totta* (72); Cape weaver, *Ploceus capensis* (124); southern-masked weaver, *Ploceus velatus* (11), yellow canary, *Crithagra flaviventris* (57); brimstone canary, *Crithagra sulphuratus* (17); streaky-headed seedeater, *Crithagra gularis* (9); Cape bunting, *Emberiza capensis* (32); and yellow bishop, *Euplectes capensis* (98)); ($K = 4.18$, $P = 0.124$; Fig. 3). The effects of fire on the six granivores with >20 encounters are illustrated in Fig. 2. Of those

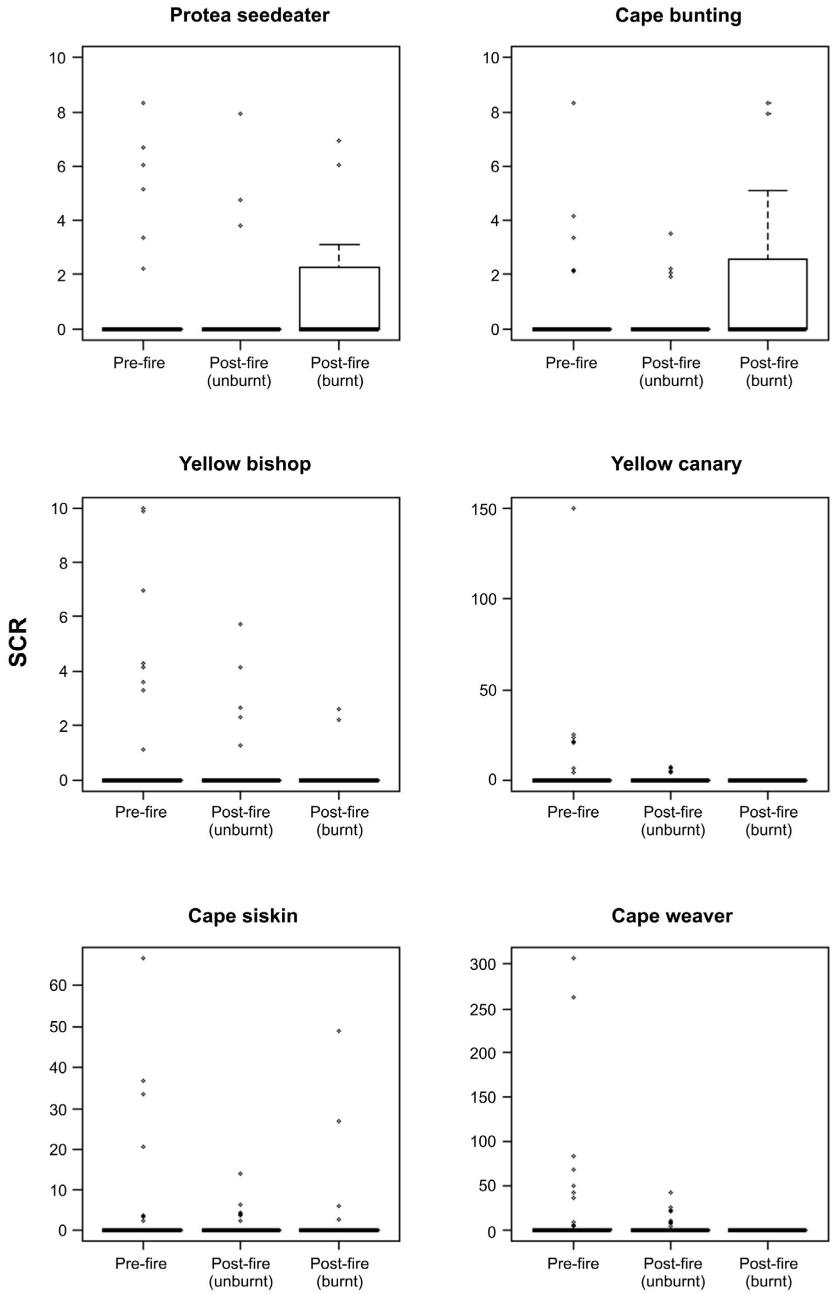

Fig. 2. Boxplots of standardized capture rates (SCR) at Blue Hill Nature Reserve for sites before and after the fire for the six most common species of granivorous birds.

where significant differences were seen, Cape bunting showed a similar capture pattern to protea seedeater ($K = 6.88$, $P = 0.03$), while Cape weavers were captured at a higher rate prior to the fire ($K = 7.67$, $P = 0.02$). Nectarivores (dominated by Cape sugarbirds, *Promerops cafer* (47% of $n = 1297$) and orange-breasted sunbirds, *Anthobaphes violacea* (30%)), showed an expected decrease in capture rates in the burnt area after the fire due to the loss of food resources ($K = 15.6$, $P < 0.001$; Fig. 3).

As protea seedeater biometric data in the litera-

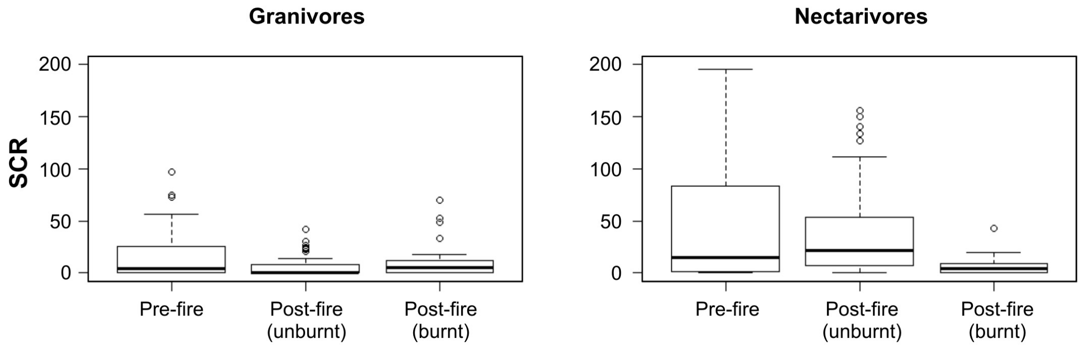

Fig. 3. Boxplots of standardized capture rates (SCR) at Blue Hill Nature Reserve for sites before the fire, and for burnt and unburnt sites after the fire, for granivorous birds (excluding protea seedeater) and nectarivores.

ture are based on only 15 individuals, we present body measurements of adult birds in Table 1. All measurements fall within the ranges presented by Dean 2005 (from Fraser & Richardson 1989; Maclean 1993), but body mass and wing lengths were smaller. All body mass measurements were taken with an Ecotone digital scale, and did not differ from those weighed by an independent ringer from the same site (20.6 ± 1.4 g, $t = -0.9$, $P = 0.4$, $n = 15$). The wing measurements for this ringer was, however, significantly smaller compared to those reported in Table 1 (69 ± 0.9 mm, $t = -3.5$, $P = 0.01$).

Based on the small comparative sample size (and possible differences in methods with respect to taking wing measurements), we do not wish to emphasize the significance of these results: previous measurements were of birds in winter rainfall regions 27 years ago. The temporal and spatial differences of the samples confound any discussion with respect to how Bergman's rule (increasing body size in relation to decreasing temperature) may be the reason for these differences. Differences could be due to clinal variation across the species' range, commensurate with changing rainfall and temperature regimes from west to east across the Fynbos (but there are no published comparative metric data for birds), or manifestations of climate change on the entire population (e.g. Yom-Tov *et al.* 2006).

During the study period, two nesting efforts were observed, neither of which resulted in fledged young. A protea seedeater nest with a single egg was discovered on 23 October 2011 (Fig. S1a,b in online supplement), approximately 1.5 m above ground in a 2-m-tall female *Leucodendron rubrum* (Proteaceae), on a steep, rocky, south-facing slope. The open cup nest conformed to the description in Tarboton (2011). On 1 November a single bird was brooding four eggs. When the nest was next checked on 14 November it had been depredated, and from tracks and character of the damage to the nest, the culprit was most likely chacma baboon, *Papio ursinus*.

A protea seedeater carrying nest building material was followed to a nest location on 2 September 2013. The nest was found in a *Searsia lucida* (Anacardiaceae) about 2 m high, with the nest

Table 1. Body measurements for protea seedeaters netted in aseasonal rainfall mountain Fynbos. We present data from Dean (2005) for comparison (mean and range). Body mass is in grams, all other measurements in mm. Independent sample *t*-test results are presented for mass and wing length for which comparative data were available from the SAFRING database.

	Mean	*n*	SAFRING database	Dean (2005)	*t*	*P*
Mass	21.0 ± 1.3	79	22.1 ± 1.1 (*n* = 28)	22.2 (18.3–24.8)	–4	<0.00
Wing	70.1 ± 2.0	79	73.2 ± 3.1 (*n* = 11)	72.7 (69–78)	–4.6	<0.00
Tail	58.0 ± 2.9	78		59.3 (54–65)		
Tarsus	18.5 ± 0.6	79		17.3 (16.5–18)		
Head	30.5 ± 0.6	64		–		
Culmen	12.6 ± 1.1	79		12.4 (12–12.8)		

1.6 m high. This nest had four eggs on 24 September and downy chicks were observed five days later. By 7 October the nest was empty, presumed predated.

On 14 November 2012 two recently fledged protea seedeaters (marked yellow gape, short tail) of what appeared to be a clutch of three (a third bird was observed close to the site of capture) were captured in seven-year old Fynbos at a separate site 12 km from BHNR. A search for the nest was unsuccessful. Three of seven individuals captured in December were judged to be immature based on plumage and gape.

Feather moult is normally timed in passerines to occur immediately after the breeding season. Two protea seedeaters were recorded with active primary feather moult; one in December 2011 and a second with more advanced primary feather moult in January 2013. A further four were judged to have recently completed their wing moult in January 2013. No primary feather moult was recorded during the remainder of the year.

The presence of a nest, fledglings, juvenile stages and primary feather moult point to a spring (Oct–Dec) breeding season, perhaps coinciding with the end of the flowering season and seed onset season for the dominant protea species in the Kouga mountains. While this is also the spring period and breeding season for most other passerines in the area, reproduction in canaries is independent of photoperiod and more dependent on food availability (Leitner *et al.* 2003). Breeding data presented here (Oct–Dec) are in agreement with both the clutch size and laying date information summarized by Dean (2005) and Tarboton (2011). Fraser (1997) also reports atlas breeding records spanning September–December.

Protea seedeaters were often observed during meandering transects feeding on the ground around burnt *Protea repens* bushes in Mountain Fynbos after the fire, where they had not been observed prior to the fire. During a ringing session on 20 June 2012, a protea seedeater was beheaded in the net by a Common Fiscal *Lanius collaris*. This showed that protea seedeaters are effective seed predators: a necropsy revealed crop content containing freshly germinating *Protea* sp. seeds, with seeds in the stomach too finely ground to be identifiable. The presence of loose flocks (>20 individuals) of this species during 2012 among burnt protea stands together with the necropsy, suggest that this species was more abundant after the fire in response to the release of large quantities of *Protea neriifolia* and *P. repens* seeds. Most protea species are serotinous, i.e. they protect their seeds from predation by holding them on the plant until a fire event. No large aggregations of birds were observed a year after the fire, although pairs and small groups (<5 individuals) were observed. By this stage protea seedlings were well established.

Milewski (1976) noted that of 115 encounters with foraging birds, median group size was 1, but that a flock of 20 individuals was observed at recently loosened seeds from *P. neriifolia* 38 days after a fire. However, he also concluded that the species depends on mature stands of Fynbos. The protea seedeater is not closely associated with protea seeds, as seen with Cape sugarbird and flowering proteas, as it is capable of foraging on a range of other seed and other plant components. In Milewski's (1976) two year study, proteas accounted for just under 30% of 200 feeding occasions, followed by *Restio* (15%) and *Senecio* (8%). Observations from our ringing exercise together with Milewski's (1976) observations suggest that protea seedeaters are capable of utilizing recently burnt protea-dominated Fynbos for the temporary abundance of available dehisced seeds, but that they rely on mature protea-dominated Fynbos at other times for other food and nesting resources.

In conclusion, in post-fire landscapes previously dominated by mature protea species, this specialized granivore (that breeds in mature Fynbos) is associated with a temporary abundance of dehisced protea seed, suggesting that protea seedeaters do respond to the occurrence of fire. The Proteaceae, a key food-plant family for protea seedeater, is negatively impacted by the increasing fire return intervals. In the eastern regions of the Fynbos, fires are observed over wider areas (Kraaij *et al.* 2012) which may pose a threat to the protea seedeater as most protea species require >7 years in order to produce reproductively useful seed banks (Rebelo 1995).

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