Accepted: 11 May 2017

DOI: 10.1111/aje.12445

SHORT COMMUNICATION

WILEY African Journal of Ecology

Habitat associations of the critically endangered São Tomé Fiscal *Lanius newtoni*: Comparing standard and playback-confirmed point counts

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Funding Information
BirdLife International; Royal Society for the Protection of Birds; Disney Worldwide Conservation Fund; U.S. Fish and Wildlife Service Critically Endangered Animals Conservation Fund, Grant/Award Number: AFR-141 1 – F14AP00529; Mohammed bin Zayed Society Species Conservation Fund, Grant/Award Number: 13256311; Nottingham Trent University; Chester Zoo; Portuguese Government's Science and Technology Foundation, Grant/Award Number: SFRH/BPD/91494/2012, SFRH/BPD/100614/2014

1 | INTRODUCTION

The island of São Tomé, in the Gulf of Guinea, is an endemism hotspot of global conservation significance (Buchanan, Donald, & Butchart, 2011), with the highest number of endemic bird species for an island of its size (Melo, 2007). It hosts 17 single-island endemics, nine of which are considered threatened, including three critically endangered species (BirdLife International 2014): Dwarf Olive Ibis (*Bostrychia bocagei*), São Tomé Grosbeak (*Neospiza concolor*) and São Tomé Fiscal (*Lanius newtoni*, herein fiscal).

Studying the habitat requirements of the fiscal has been identified as a conservation priority for the species (BirdLife International 2014); furthermore, the biology of the fiscal is relatively unknown. Until recently, the only information available from observations stated that it tends to sit on perches between 3–5 m to scan for prey (Christy & Clarke, 1998) and that they are associated with watercourses, where canopy is less dense (Jones & Tye, 2006; Olmos & Turshak, 2010). The fiscal is known only from well-preserved forest, with low understorey density and in areas of high rainfall (Jones & Tye, 2006). Historically, it was considered a lowland forest bird (Jones & Tye, 2006), but along with other evidence (Atkinson, Peet, & Alexander, 1991; Jones & Tye, 2006; Maia & Alberto, 2009; Schollaert & Willem, 2001; Sergeant, 1994), recent work carried out by Lima et al. (2016) has better defined the shrike's range. It is now confirmed to inhabit mid-altitudes south of Pico de São Tomé and around Cabumbé Peak in native forest mostly within Obô Natural Park.

Here we build on the work of Lima et al. (2016), providing a valuable contribution to the existing knowledge of the shrike. By comparing survey methodologies at a fine scale, this study will establish an efficient methodology to monitor the species whilst also increasing our understanding of its habitat associations.

2 | MATERIALS AND METHODS

2.1 | Study site

The Democratic Republic of São Tomé and Príncipe consists of two small oceanic islands located in the Gulf of Guinea (Central Africa 0°01′08″–0°24′27″N, 6°27′43″–6°45′39″E). The study took place in the south-west of the island of São Tomé, within the Obô Natural Park. The study area covered 400 ha of old growth forest in an area of rugged terrain, at the lower end (200–800 m) of the fiscals' full

altitudinal range (100–1,345 m) (Jones & Tye, 2006; Lima et al., 2016; Maia & Alberto, 2009). The area was chosen as it had been identified as an important area for the fiscal (Lima et al., 2013, 2016).

2.2 | Point counts

Point counts and habitat assessments were used to identify habitat associations. Two methods of carrying out point counts were used: a standard methodology and playbacks. This was done to improve detection and reduce the number of false negatives. Surveys across 61 point locations were carried out during the main dry season, between the 31st of May and 17th of July 2015 (Figure 1). Point counts were positioned along six transects, the first point along each transect being placed at random. The coordinates of each point were taken by GPS (Garmin eTrex 10, Garmin Ltd, UK). The points were 150–200 metres apart, a distance considered adequate to ensure independence between point counts (Hutto, Pletschet, & Hendricks, 1986). At each point, an initial 3 min settling period was used to allow birds to resume normal behaviour (Bibby, Burgess, & Hill, 2000). Sampling was performed by two observers, observer bias was considered negligible, as the shrikes' call is extremely distinctive (Jones & Tye, 2006). At each point, the number of fiscals detected within a 25-m radius, for 10 min after the resting period was recorded. Point counts took place between 06:00 and 11:00. To maximize detection and avoid biases related to sampling period, each point was visited at three different times.

If no fiscal had been detected during the standard sampling period, 10-s playbacks were carried out after the point count. Any response was recorded within the 30 s after the playback, an interval considered sufficient to elicit a response from individuals within a 25-m radius, but short enough to reduce the risk of individuals approaching from beyond that limit (Sliwa & Sherry, 1992). Playbacks were carried out using the recording in Chappuis (2000), through speakers (Mini Amplifier/Speaker, RadioShack Technologies, USA), using an iPod (iPod Touch 4th Generation, Apple Inc., USA). Vegetation metrics were obtained around each point count (Table 1).

2.3 | Statistical analysis

Analyses were carried out using R v. 3.1.1 (R Core Team 2014) in RStudio (RStudio Team 2015). Generalized linear models (GLMs) were used to identify associations between habitat features and the presence of the fiscal. Playback-confirmed models used data from both standard point counts and playbacks, whereas the standard point counts used data only from the 10-min point counts. The "dredge" function from the "MuMIn" package was used to test models defined by all possible variable combinations and rank them by their AICc-based model weight (Barton, 2013; Burnham & Anderson, 2003). Model averaging and relative variable importance output from the "model.avg" function were used to identify key variables.

3 | RESULTS

In the 183 10-min point counts, there were 40 registrations of the fiscal within a 25-m radius over 28 different points. Playbacks were used 140 times at 56 points where fiscals had not been recorded during the standard point count. Thirty-three shrikes were recorded during the 30-s playbacks. In addition, 27 birds were heard during the point counts outside the 25 m point count radius, and 18 were found incidentally, outside the point counts and playbacks.

3.1 | Habitat associations

3.1.1 | Standard models

The variables with the strongest support in predicting fiscal presence using count data were elevation and mid-storey density between 2 and 5 metres (M1), being present in every top model (Table 2, Table S1). The relationship between standard presence and elevation is positive within the sampling range (200–800 m; Figure 2a).

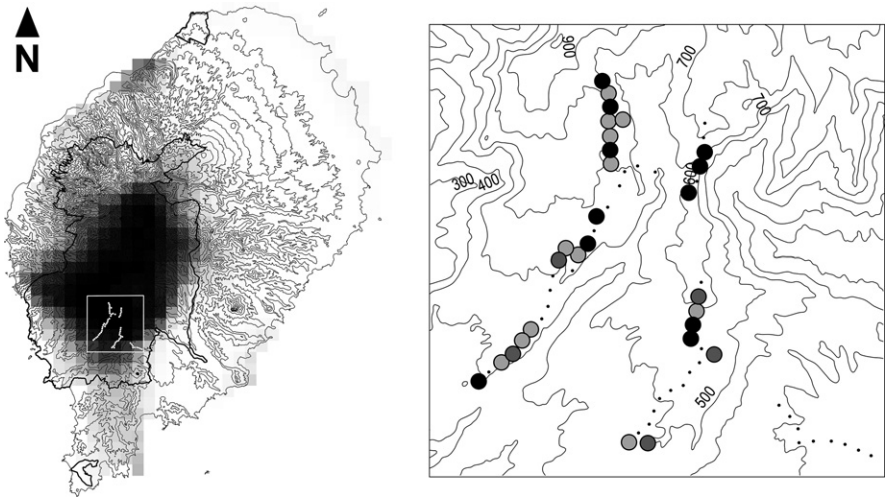

FIGURE 1 Study site map of São Tomé, showing the study site relative to the whole island and the study showing point counts. White dots show points where fiscals were only detected during point counts, grey dots show points where fiscals were detected using only playbacks, and black dots show point counts where fiscals were detected using both methods

TABLE 1 Variable names, method used to collect and radius around central point

Variable	Description	Radius
Average canopy height	Estimated by a trained observer, within 5-m bands (Freemark & Merriam, 1986)	25 m
Mid-storey density (2–5 m) Mid-storey density (5–10 m) Mid-storey density (10 m to canopy)	Split into three categories (1 = open to 3 = high density)	25 m
Number of canopy trees	Count of all trees above 30 cm diameter at breast height	25 m
Epiphyte density	Split into three categories (0 = none to 3 = high)	25 m
Canopy density	Average of measurements taken using a convex spherical densiometer at points in the four cardinal directions (Lemmon, 1956; Strickler, 1959)	Measurements taken at four points 5 m from centre point at each cardinal direction. But measurements refer to a larger area as instrument uses a convex lens
Understorey density	Counting the number of stems touching a 1 m pole at 1 m from the ground, at each of the four cardinal directions	Four points 5 m from centre point at each cardinal direction
Number of ferns	Exact count of ground ferns	5 m

3.1.2 | Playback-confirmed models

The variable with the strongest support for the playback-confirmed data was canopy density, being part of every top model (Table 2, Table S1).

4 | DISCUSSION

The standard point count models support the findings of Lima et al. (2016), reinforcing how elevation and mid-storey density are important factors determining the distribution of the fiscal. Elevation is likely a proxy for abiotic factors such as temperature, precipitation and geomorphology that influence biotic factors such as forest and faunal community composition. Whilst it was beyond the scope of this study to identify drivers behind habitat associations, invertebrate diversity and abundance are likely to play a central role in the distribution of the fiscal (Kuper, Van Duinen, Nijssen, Geertsma, & Esselink, 2000; Lepley, Thevenot, Guillaume, Ponel, & Bayle, 2004; Padilla, Nogales, & Pérez, 2005; Soobramoney, Downs, & Adams, 2004), as all feeding records for the species were of invertebrates (Christy & Clarke, 1998; Jones & Tye, 2006; T. C. Lewis, pers. obs.).

TABLE 2 Relative importance of habitat variables in the standard and playback models on the presence of fiscal from the GLM dredge function

Model	Variable	Relative importance
Standard	M1	**0.97**
	Elevation	**0.96**
	Ferns	0.42
	Canopy density	0.38
	Understorey density	0.24
	Epiphytes	0.23
	M2	0.09
	Average canopy height	0.01
Playback	Canopy density	**0.99**
	Understorey density	0.52
	Elevation	0.49
	M1	0.43
	Ferns	0.26
	M2	0.11
	Epiphytes	0.03
	Average canopy height	<0.01

The most important terms are in bold.

Invertebrate species diversity is known to increase at intermediate altitudes (Brehm, Colwell, & Kluge, 2007; Wronski et al., 2014) due to a more stable climate, with the highest humidity and moderate temperatures (Kluge, Kessler, & Dunn, 2006).

Coupled with elevation, there is a negative relationship between high-density mid-storey (at 2–5 m) and the presence of the fiscal (Figure 2b). This is consistent with observations by Christy and Clarke (1998) who found that the fiscal prefers to perch at 3–5 m to scan for prey. The fiscal occurs in denser forests than other fiscals (Yosef, 2008), such as its sister species *Lanius mackinnoni* (Fuchs, Crowe, & Bowie, 2011; Harris, 2010). Nevertheless, our results show it uses more open microhabitats. This, along with the negative relationship between canopy density and presence of the fiscal (Figure 2c), further supports the view that the species has adapted to exploit the niche within the forest which is most similar to that of its relatives. That is to say, the preference for more open areas enabled it to adapt to a totally forested island without dramatically altering its hunting behaviour. This coincides with the observations that suggest fiscals are associated with watercourses (Jones & Tye 2006, Olmos & Turshak 2010), where forest canopy is less dense.

4.1 | Model comparisons

As the species can be discreet and even silent in areas where it seems to be occurring at lower densities, playback-confirmed presence may give a more accurate representation of the areas where the fiscal is present. Results indicate using playbacks increased detection at sites with lower canopy densities and at lower altitudes. This might be due to these areas having lower habitat quality; therefore, population density is lower and territory distribution is patchier making it harder to detect the birds. Although generalizations about habitat quality and species

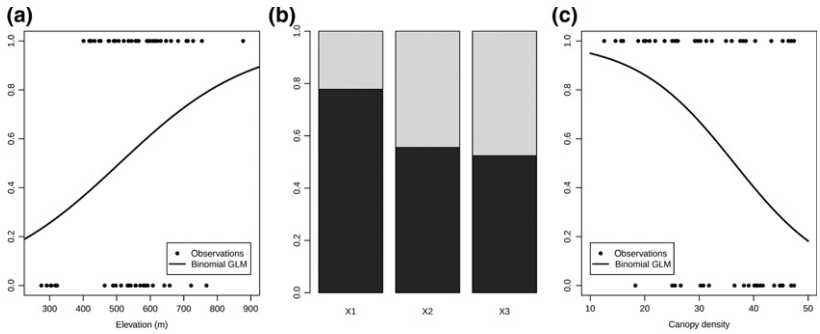

FIGURE 2 Observed presence of the fiscal for (a) elevation (standard) with predicted presence (b) midstorey density (standard) (c) canopy density (standard) with predicted presence.

density can lead to erroneous conclusions (Van Horne, 1983), lower density in territorial birds normally corresponds to lower-quality habitat (Bock & Jones, 2004). The territory size and territoriality of the fiscal are unknown, but if the species is less vocal when it occurs at lower densities, it is consistent with our results that detectability during the standard point counts decreases. As territories in lower-quality habitats are likely to be larger than high-quality ones (Bock & Jones, 2004), birds may be drawn to and respond to a perceived intrusion from a greater distance, attracting the birds to point and biasing results. The results indicate in most of the areas surveyed the fiscals' distribution is patchy, possibly mirroring the patchiness of quality habitat.

It would be expected that attracting birds into areas they do not usually utilize and measuring variables on a small scale would weaken any relationships. Evidently, this study shows elevation has a strong relationship with the standard data but that it is only the third most important variable in the playback-confirmed model (Table S1). Thus, using playbacks would be a useful tool for monitoring and to map its distribution, as it can improve detection.

4.2 | Breeding biology

Three juvenile sightings were made during this study, all occurred within typical lowland forest: high gallery canopy with dense understorey. The first two were estimated to be 5–11 months old and were moulting into their adult plumage (Chapman, 1995; M. Melo pers. obs.); the third was thought to have fledged between April and July (Chapman, 1995). Birds in full juvenile plumage had previously only been found in January (M. Melo pers. obs.), indicating the fiscal breeds from November to July. However, the dispersal patterns of the fiscal are not known and the implications of observing these juveniles in areas of perceived low-quality habitat are not clear. Possibly, the juvenile sightings during this study suggest optimal habitats are filled by mature birds, forcing young birds into suboptimal habitats, although more evidence is needed to support this idea.

5 | CONCLUSION

This study supports findings from Lima et al. (2016) in suggesting *L. newtoni* is a forest-dependent, open canopy-associated species that prefers intermediate elevations. Additionally, here we describe a significant presence in lowland forest, despite higher densities at higher altitudes. However, this could be due to the use of playbacks increasing the detection of the more inconspicuous juveniles or young birds in lowland habitats.

The discovery of high population densities of the São Tomé Fiscal in remote areas with difficult access is positive news for this critically endangered species. The species should be monitored together with the impact of pervasive threats. Particularly, invasive species and forest extraction activities, like hunting and wine palm gathering, are encroaching into the more accessible areas at the edges of its range. This poses a serious threat not only to the fiscal, but also to the long-term conservation of São Tomé's endemic-rich native forests.

ACKNOWLEDGEMENTS

This work is part of BirdLife's São Tomé and Príncipe Initiative, which was funded by BirdLife's Preventing Extinctions Programme through the Prentice family (as part of BirdLife's Species Champion Programme), the Royal Society for the Protection of Birds, the Disney Worldwide Conservation Fund, the U.S. Fish and Wildlife Service Critically Endangered Animals Conservation Fund (AFR-1411 – F14AP00529) and the Mohammed bin Zayed Society Species Conservation Fund (Project number 13256311). We would also like to thank Nottingham Trent University and Chester Zoo for additional funding for the project and the General-Director for the Environment of São Tomé and Príncipe, Arlindo Carvalho, for giving us permission to conduct our work. Special thanks go to our guide on São Tomé, Ricardo da Fonseca "Mito," whose knowledge of the forests and wildlife of São Tomé is incredible. Ricardo Faustino de Lima and Martim Melo were supported by Postdoc fellowships from the Portuguese Government's Science and Technology Foundation (SFRH/BPD/91494/2012 and SFRH/BPD/100614/2014, respectively).

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SUPPORTING INFORMATION

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How to cite this article: Lewis TC, Melo M, de Lima RF, Bremner-Harrison S. Habitat associations of the critically endangered São Tomé Fiscal *Lanius newtoni*: Comparing standard and playback-confirmed point counts. *Afr J Ecol*. 2017;00:1–5. https://doi.org/10.1111/aje.12445