Association with riparian fragments by Yellow-breasted Boubou *Laniarius atroflavus* indicates need for wider-scale forest matrix conservation

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Summary

We investigated habitat association in the range-restricted Yellow-breasted Boubou *Laniarius atroflavus* across three montane forest habitats in and around the Ngel Nyaki Forest Reserve on the Mambilla Plateau, Nigeria. The habitats were: officially protected forest interior (forest core), protected but disturbed forest edge, and unprotected riparian forest fragments. Census data were collected using point counts between November 2009 and September 2010, and were analysed by multivariate correspondence analysis. Yellow-breasted Boubou home ranges were identified and delineated, and numbers compared across habitats. The Yellow-breasted Boubou demonstrated the strongest habitat association with the riparian habitat. This finding adds to the case for a mixed forest-matrix conservation scheme to incorporate the conservation and protection of the riparian habitat, not just the forest core and edge habitats.

Résumé

La fréquentation de fragments de forêts-galerie par le Gonolek à ventre jaune *Laniarius atroflavus* est indicatrice du besoin de conservation d'une matrice forestière plus vaste et plus variée. Nous avons étudié la fréquentation par habitat du Gonolek à ventre jaune *Laniarius atroflavus* à travers trois habitats de forêts de montagne à l'intérieur et autour de la Réserve de la Forêt Ngel Nyaki sur le plateau Mambilla, au Nigeria. Il s'agissait des habitats suivants: intérieur de la forêt officiellement protégé (cœur de la forêt), lisière de la forêt protégée mais perturbée et fragments de la forêt-galerie sans protection. Des comptages ont été effectués à partir de points d’écoute entre novembre 2009 et septembre 2010, et fait l’objet d’une analyse factorielle des correspondances. Les domaines vitaux des Gonoleks à ventre jaune ont été identifiés et définis, et les comptages comparés par habitats. L’espèce a montré sa forte fréquentation de l’habitat de forêt-galerie. Ces résultats viennent renforcer les arguments en faveur de la conservation d’une matrice forestière constituée de milieux variés qui inclurait la conservation et la protection de l’habitat de forêt-galerie, et pas seulement le cœur de la forêt et sa lisière.

Introduction

Conservation action tends to focus on the least degraded habitats at the highest level of ecological succession (Hoekstra *et al.* 2005, Forboseh *et al.* 2007), and neglect marginal habitats (Kupfer *et al.* 2006). Justification for this approach is that because resources for conservation are limited, they should be spent on maintaining habitats and species whose future looks promising, rather than gambling on habitats in which the ecological resilience or potential for recovery has been jeopardised by land-use changes and related activities (Pons & Quintana 2003). However, this reasoning can be flawed because some species are adapted for optimum resource utilisation in habitats at lower levels of ecological succession (Finch 1989), which illustrates the need to investigate habitat association when making conservation decisions around focal species. Some species are habitat generalists, such that individuals use a range of habitats in the course of their life history or individuals are resident across different habitat types. In such cases, it is not always obvious which habitat is the most important for the persistence of the species, yet this is a critical question because constrained resources mean that priorities have to be determined in terms of which habitats are protected. The limited resources for conservation must be allocated towards the habitat which is most preferred by individuals of the targeted species (Bennun *et al.* 2005).

The need to identify habitat association correctly is of particular concern in the conservation of endemic and range-restricted species, because such species are at greater extinction risk from localised events. The Yellow-breasted Boubou *Laniarius atroflavus* is one such range-restricted species. A sedentary, monogamous, territorial and monomorphic bush-shrike (family Malaconotidae), it is restricted to the montane forest landscape of south-eastern Nigeria and western Cameroon at elevations of 700–2900 m. It has generally been reported to inhabit the dense undergrowth of clearings along streams, thickets, secondary scrub, small remnant forest patches and bamboos in ravines and on ridges (Fry *et al.* 2000, Hoyo *et al.* 2009). Though listed as a species of Least Concern on the IUCN Red List (<http://www.iucnredlist.org/details/22707597/0>, consulted Jan 2014), *L. atroflavus* is of conservation interest as a result of its range restriction, and consequently the presence of breeding populations at any site fulfils a criterion for the designation of the site as an Important Bird Area (IBA; Fishpool & Evans 2001). The global population of this bird can be found within only 11 IBAs (<http://www.birdlife.org/datazone/speciesfactsheet.php?id=6178&m=1>, consulted Jan 2014).

Working at one of these IBA sites, we set out to investigate habitat association in *L. atroflavus* across the range of potentially suitable montane forest habitats. We examined the location, number and size of home ranges occupied by individuals of this species across the different forest habitat types.

Materials and methods

Study area

Ngel Nyaki Forest Reserve (7°5′10″N, 11°4′0″E) is located on the Mambilla Plateau in Taraba State, eastern Nigeria, close to the border with Cameroon. The reserve has an area of 46 km^2, of which the escarpment forest covers 7.2 km^2 (Chapman & Chapman 2001, Fishpool & Evans 2001). The Ngel Nyaki forest is on the steep slopes of an ancient volcano between 1400 and 1600 m (Chapman *et al.* 2004). Surrounding the main escarpment forest block is overgrazed grassland which is criss-crossed by streams historically fringed with riparian forest (Chapman & Chapman 2001). The entire forest landscape, forest block and riparian fragment, is threatened by fragmentation and degradation through burning, grazing, collection of wood for fuel and fence posts, and poaching.

In addition to its IBA status, the reserve is an Endemic Bird Area (EBA) as part of the Cameroon highlands, identified for the conservation of the Sudan-Guinea Savanna, Guinea-Congo Forest and Afrotropical Highland biomes (Fishpool & Evans 2001). There are also the IUCN Red-listed tree species *Entandrophragma angolense* and *Pouteria altissima*, the endangered Nigerian Chimpanzee *Pan troglodytes vellerosus*, and the Putty-nosed Monkey *Cercopithecus nictitans martini* and Buffalo *Syncerus caffer* at and around the site (Chapman *et al.* 2004).

The 6.5 km^2 study area covered the central and eastern portion of the 7.2 km^2 main escarpment forest block, within which *c*. 2.25 km^2 of escarpment forest interior (hereafter referred to as forest core habitat), and 2.25 km^2 of escarpment forest edge were identified, along with a 2 km^2 area of grassland containing riparian forest fragments scattered within it (Fig. 1). Forest core habitat is defined as escarpment forest at least 200 m from any surrounding grassland. The forest core (Fig. 2a) is protected and characterised by emergent trees up to 35 m tall, such as *E. angolense* and *P. altissima*. The canopy is approximately 20 m high and comprises species such as *Carapa procera*, *Santiria trimera* and *Newtonia buchananii*. The forest edge (Fig. 2b) is also protected and covers the 200 m buffer around the forest core habitat, the vegetation structure of which does not exhibit many emergent trees, but with an abundance of mid-storey tree species including *Albizia gummifera*, *Anthonotha noldeae*,

Figure 1. Google Earth image of Ngel Nyaki FR showing the forest core (grey polygon), edge (black polygon) and riparian (white polygon) study areas.

Ficus sp. and *Isolona deightonii*. The unprotected riparian fragments comprise narrow strips of forest bordering ephemeral grassland streams (Fig. 2c), with the vegetation made up predominantly of dense undergrowth of lianes, shrubs and ferns; *Psychotria penduncularis* and *Dracaena fragrans* are common (Chapman & Chapman, 2001, Chapman *et al.* 2004).

Bird census

Between November 2009 and September 2010 we conducted 11 monthly point count exercises in each of the three forest habitats for all bird species following methods described by Ralph *et al.* (1995) and Bibby *et al.* (2000). Each point count observation spanned a five-minute period, and due to variation in the visibility in the three habitats, only bird species seen or heard within a 25-m radius were recorded. Eight survey points were established along pre-existing transect lines in each habitat. Using a Garmin Oregon 550 GPS receiver and satellite imagery from Google Earth, each point was set at least 250 m apart assuming that observations made at each point would then be independent of those made at the next. All observations were made by the same observer (Y. Vugeh), to eliminate inter-observer bias in the data collected.

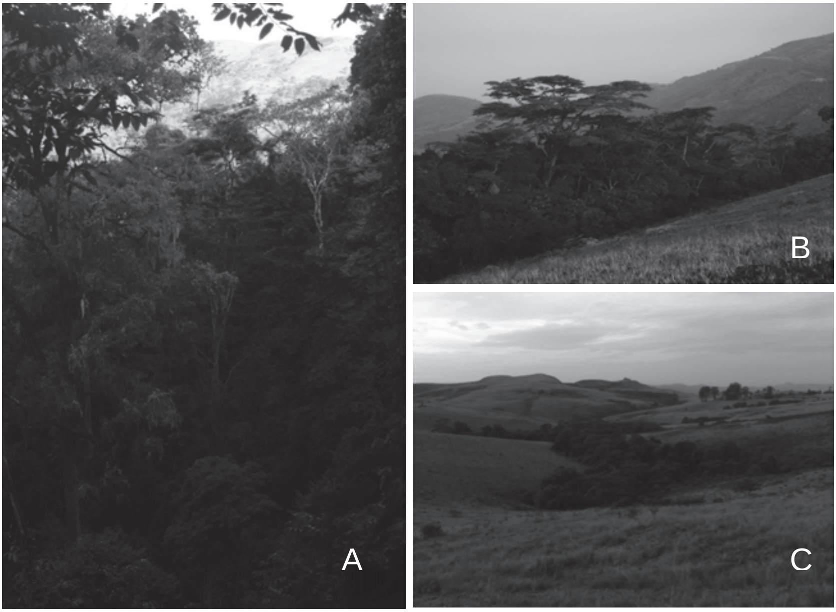

Figure 2. Examples of the three habitats: A forest core; B edge; C riparian.

Data were collected from one transect per day, between 7h00 and 10h00, with slight variation in time depending on distance to the start of the transect line, transect length and accessibility. The start of each transect was alternated between the two ends at different visits to reduce bias from the time of day when any particular point was reached.

We used the dataset to explore the association of *L atroflavus* with habitats, defined as the relative abundance of the focal species in each of the three habitats; we assumed that bird species repeatedly recorded from only one habitat exhibit strong association with that habitat (Pearman 2002). Correspondence analysis was used to quantify habitat association from the census data (Shrestha & Wegge 2008). The data were scaled by species and weighted by habitat, and the cyclic Jacobi algorithm (Drmač 2009) was employed to generate two axes, allowing a two-dimensional assessment of association. Axis values of habitats (core, edge and riparian) and bird species were both extracted and compared. Strong habitat association of any avian species with a particular habitat was indicated by equal axis values for the bird and that habitat. In the case of *L. atroflavus*, equal values were not recorded with any particular habitat, so a proximity index was calculated using the sum of squares formula $a^2 = b^2 + c^2$, where b is the difference in value along axis 1 between *L. atroflavus* and each habitat, and *c* is the value along axis 2. The lower the proximity index value *a* to any habitat, the stronger the association between the bird and the habitat.

Home range mapping

The density and size of *L. atroflavus* home ranges in the study site were assessed using a combination of telemetry and territory mapping. These were conducted between November 2009 and March 2011, but effort was made not to undertake telemetry and mapping within the same home range and at the same time period as the bird census. Telemetry involved the use of single-stage glue-on radio transmitters (Sirtrack Ltd, Havelock, New Zealand) with an estimated signal range of 1 km, and 30 pulses per minute (set to optimise the battery life of the transmitter, *c*. 60 days, while ensuring a pulse reading that was sufficiently high). Over the study period, a total of 14 birds from 11 home ranges were trapped using mist nets. As the birds are sexually monomorphic, it was not possible to sex them by external characters. However, using genetic sexing methods, it we identified eight females and six males, with three females and two males trapped in the edge habitat, and five females and four males trapped in the riparian habitat. In the three home ranges where two individuals were successfully trapped, they were found to be male and female, indicating that home ranges are occupied by a heterosexual pair. A radio transmitter with a unique transmission frequency between 148 and 152 MHz, specific to the frequency range of the ATS R410 digital receiver (Advanced Telemetry Systems Inc., Isanti, U.S.A.) was glued to the mantle feathers of each trapped and colour ringed bird. The unique frequency of each transmitter enabled the tracking of several radio-tagged birds at the same time, by adjusting the frequency of the receiver to each frequency. The radio-tagged birds were then released from the point of capture. Thereafter, a set of four points was established around and just outside of the area of forest where each individual's home range was suspected to be (*i.e.* the area where the bird was captured) and the coordinates of each of the four points were noted. To identify the location of the radio-tagged birds, record taking was done hourly in the morning (5h00–10h00), afternoon (12h00–14h00) and evening (16h00–18h00). During each hour of record taking, the location of the bird from each of the four points (following the signal from the transmitter on the bird) was determined using the receiver equipped with a three-element folding Yagi antenna. When the location of the bird (direction of the strongest radio signal) was determined, a prismatic compass was used to record the bearing of that location from the point. It took approximately 35 min. to traverse each set of four points around each assumed home range of a radio-tagged bird, after which the observer waited for the next hour and repeated record-taking in reverse. The bearing angles from each of the four points were used to generate projection lines in Forward/Inverse (Mentor Software Inc., Littleton, U.S.A.). The coordinates of each projection line were then entered into Map Source (Garmin Ltd., Olathe, U.S.A.). In Google Earth, the points where several projection lines crossed were marked as locations of the bird. Radio tracking and record taking continued until either the transmitter battery died or the transmitter fell off the bird, in which case the transmitter was retrieved and used on the next trapped bird.

The supplementary method used to delineate *L. atroflavus* home ranges was a modification of the more traditional territory mapping method (Bibby *et al*. 2000). The trapped *L. atroflavus* individuals were colour-ringed and, during subsequent sightings, GPS records were made of the locations of the birds. Over time and repeated observations the collection of GPS points was entered into Google Earth as described above, and a polygon was defined around them, using the minimum convex polygon approach (White & Garrott 1990) to join the points. Though the minimum convex polygon method has been criticised for unpredictable bias (Barg *et al*. 2005), we did not carry out a variance component analysis (Nilsen *et al*. 2008) but simply present baseline home range information. The polygons were converted to Map Source files, then the area of the polygon determined and used as home range size. Repeated observations of non-ringed birds were also used to identify (but not delineate) other home ranges, in sites where the birds were not successfully trapped. The possibility exists of two neighbouring home ranges monitored in this way being recorded as one (or *vice versa*) but the distribution of such ranges suggests this was not the case (see Fig. 3).

Statistical analyses

The correspondence analysis was performed using the multivariate statistical package MVSP (Kovach Computing Services, Anglesey, U.K.). Differences in proximity indices and home range sizes between habitats met the parametric criteria of normal distribution (tested using the Shapiro-Wilk test) and equal variance (tested using Levene's test) and were analysed using ANOVA. These statistical analyses were performed in R (R Development Core Team, Vienna, Austria) at a 95 % confidence interval.

Results

In total, 16 *L. atroflavus* home ranges were identified in the 6.5 km^2 study area by telemetry and territory mapping of 14 radio-tagged and colour-ringed birds, and repeated observations of non-trapped birds. Five home ranges were identified in the edge habitat and 11 in the riparian. One *L. atroflavus* home range was found in the forest core area, but at a location with a break in the forest canopy offering a vegetation structure similar to the edge habitat: as such this one was recorded as one of the five edge-habitat home ranges. Sufficient location points were gathered to delineate the shape and size of nine home range: three in the edge habitat and six in the riparian habitat (Fig. 3). The mean *L. atroflavus* home range size was 6094 ± 1259 (SD) m^2, with no significant difference ($F_{1,7}$ = 0.259, P = 0.627) between the edge habitat (5777 ± 1340 m^2) and the riparian habitat (6252 ± 1314 m^2).

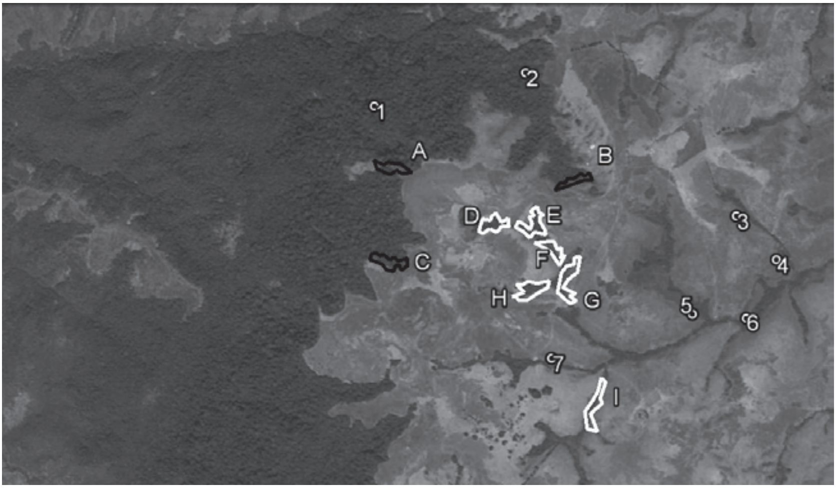

Figure 3. Google Earth image with polygons (A–I) indicating the location and shape of *L. atroflavus* home ranges in the edge (black lines) and riparian (white lines) habitats, and spots (1–7) indicating the location of *L. atroflavus* home ranges in which it was only possible to determine occupancy.

The monthly proximity index *a* of *L. atroflavus* was significantly different ($F_{2,30}$ = 35.944, $P < 0.001$) for each of the three habitats (Fig. 4). The association was strongest with the riparian habitat (0.77 ± 0.41 SD), then edge (2.21 ± 0.68 SD), and weakest for the forest core habitat (2.59 ± 0.46 SD). This result was obtained despite the fact that the far-reaching call of *L. atroflavus* was occasionally difficult to place as within or beyond the 25-m point count radius, especially within the forest core, resulting in more census records at points within the forest core when compared to the location of home ranges determined by the other methods.

Discussion

Our results demonstrate that *L. atroflavus* exhibits strongest association with the riparian habitat, with more home ranges identified in the riparian fragments. This could be due to the vegetation structure of the riparian being denser and potentially affording a lower risk of nest predation for this species (S.T. Osinubi, unpublished data). Alternatively, there are indications that *L. atroflavus* prefers habitats offering running water, as all of the *L. atroflavus* home ranges found in the riparian habitat offered water sources and three of the five territories in the edge habitat were within 50 m of open water. Home range intrusion or overlap was not observed during this study,

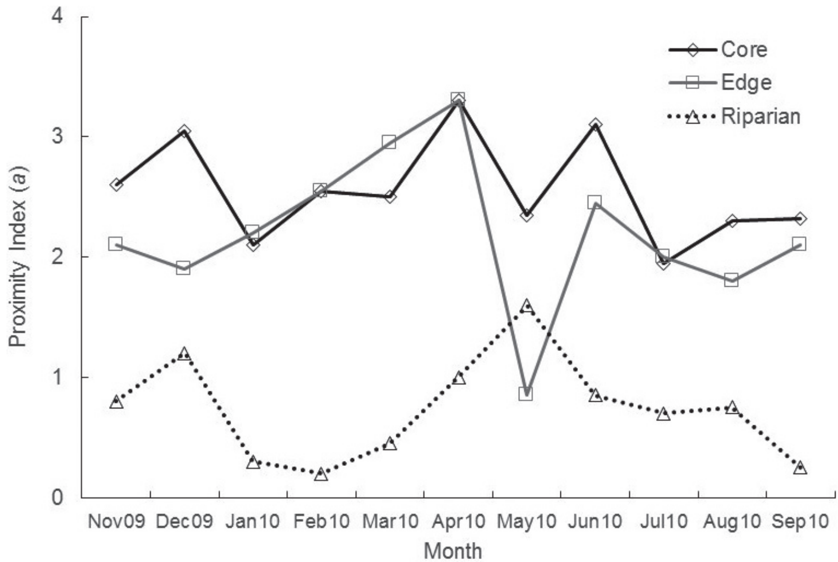

Figure 4. Low values of monthly proximity index *a* (see text) indicate that *L. atroflavus* demonstrated strongest association for riparian habitat and weakest for forest core habitat.

even where home ranges were close together as observed in the riparian habitat, suggesting that this species has well-defined boundaries. Individuals only approached to investigate calls coming from within their own home range. It would appear that range fidelity is also strong, as individuals were observed to occupy the same ranges all year round. There was only one home range where the breeding pair appears to have been replaced, by a Tropical Boubou *L. aethiopicus* between the 2009 and 2010 breeding seasons. We do not know whether this was as a result of inter-specific displacement or the home range becoming vacant for another reason. The lack of significant difference between home range sizes in the edge and the riparian habitats did not permit the examination of home range size as indicative of habitat association (Maher & Lott 2000). Moreover, the two-dimensional estimation of home range size did not accommodate differences due to slope.

These findings identify *L. atroflavus* as a potential flagship species in the argument for the official protection of currently degraded and relatively species-poor riparian fragments in Nigeria, and more widely across the Nigeria-Cameroon mountain range. Conservation needs to be approached from both landscape and species perspectives (Didier *et al.* 2009). Despite efforts by the Nigerian Montane Forest Project and the Nigerian Conservation Foundation within the protected area of the Ngel Nyaki FR, the unprotected riparian habitat associated with the Forest Reserve has suffered continuous illegal cattle grazing, bush burning, encroachment and poaching. These anthropogenic pressures have also been reported in the edge habitat and parts of the forest core. The narrowness of the riparian forest fragments makes them targets as watering points for cattle herders and other encroachers, whose activities break the vegetation into discontinuous strips. As the numbers of herders and their cattle increase, these disturbances are also continually increasing (Chapman *et al.* 2004). We support more focused conservation action before the habitat and the species that depend on it are lost.

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