Further notes on the natural history of the Ethiopian Bush-crow *Zavattariornis stresemanni*

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Summary. The Ethiopian Bush-crow *Zavattariornis stresemanni* is a charismatic and Endangered endemic bird of southern Ethiopia, whose general biology remains under-studied. We present field notes and observations from 2008 to 2014, covering many aspects of the species' behaviour and morphology. Bush-crows breed co-operatively in response to both of the local rainy seasons, but group size and fidelity of helpers appears to be variable. Bush-crow nests were found for the first time on man-made structures; a low power distribution pole and a tall electricity pylon. The display of one bush-crow to another is further described. Juveniles can be identified by darker coloration around the face, bright red gapes and distinctive begging calls. Adults possess lightweight, low-density body feathers and it appears that bush-crows have a moult phenology that overlaps extensively with breeding, a trait unusual in birds. Post-breeding dispersal is often limited, although anecdotal evidence and a handful of observations suggest that some individuals cover greater distances between breeding seasons. We report the first confirmed predation of a bush-crow, and supplement this with notes on other interspecific interactions. Finally, bush-crows were found for the first time north-west of Yabello (a small range extension), and we discuss the implications of local movements and range fluctuations in the context of the species' apparent climatic range limitation.

Ethiopian Bush-crow *Zavattariornis stresemanni* is an enigmatic species of corvid, apparently most closely related to Asian ground-jays *Podoces* (Ericson *et al*. 2005), and is confined to an area of park-like thornbush, short-grass savanna and pastures in southern Ethiopia. Ten years ago a reported decline in numbers (Borghesio & Gianetti 2005) led to its upgrading to the IUCN Red List category Endangered, which treatment has been maintained until the present (BirdLife International 2015). This triggered new initiatives to assess its needs more precisely (Mellanby *et al*. 2008, Donald *et al*. 2012, Jones 2013). The bush-crow is a co-operative breeder (Benson 1942, Fry *et al*. 2002) that lives in small groups, occasionally congregating in flocks of up to 30 birds, and exhibits a number of interesting social behaviours, e.g. allofeeding, allopreening and the use of bare skin around the eye in signalling (Gedeon 2006). Its range is confined to a pocket of cooler, drier and more seasonal climate than is found elsewhere in the region, which is thought to limit this otherwise common and seemingly generalist species to a global distribution of <6,000 km^2 (Donald *et al*. 2012). Here we assemble observations collected during recent research to supplement the natural history notes already provided by Dellelegn (1993), Gedeon (2006) and Ross *et al*. (2009). Further information on food and foraging will be presented elsewhere (Jones *et al*. in prep.).

The following observations were made during frequent visits by the authors between 2008 and 2014 to areas throughout the species' range, the limits of which were detailed in Donald *et al*. (2012). The locations of sites mentioned in the text are shown in Fig. 1.

In 2013, 57 birds were trapped, measured and individually colour-marked by SEIJ and AJB. Behavioural studies (outlined in Jones 2013) were conducted on these birds in 2013 and

2014. Data on individual groups' ranges were collected, broadly following a methodology outlined by Bowden *et al*. (2008): a set aspect (south) and distance (25 m) to a focal bird was adopted and the group followed on foot by 'shadowing' the bird's movements while the observer (SEIJ) tracked the path using the 'track' function on a Garmin GPSMAP 62s unit. Coordinates were then adjusted by 25m north to assess 'true' movements.

Breeding season

The species was initially reported to breed in February–March, in response to the primary wet season in the region (Benson 1942). However, breeding has since been more commonly observed in May–June, prompting the suggestion that birds 'may be double-brooded or have an extended breeding season' (Collar & Stuart 1985). There is still no solid evidence for double-brooding, but our observations support the existence of a variable or extended breeding season. It is now clear that breeding activity is influenced by annual variations in the timing and intensity of rains, as is true of the sympatric White-tailed Swallow *Hirundo megaensis* (Bladon *et al*. 2015) and many other African arid-zone birds (Immelmann 1973, Craig 2012).

Gedeon (2006) reported that the first rains in 2005 fell on 27 February, stimulating much bush-crow nest-building activity, none of which had been completed by 6 March. Between 20 and 31 May 2011, KG found a family at Dida Hara with at least one fledged but dependent juvenile, whereas most other groups were still tending nests. In 2013 AJB recorded the onset of rain at the end of March, saw birds visiting nests on 27 March, and heard young begging in nests on 29 March and 6 April. He and SEIJ observed the first fledgling on 9 May, but another pair was observed building a new nest as late as 11 May (SEIJ), and some were still tending young in the nest at the end of the month; possibly these were inexperienced birds or individuals that had ceased helping other groups partway through the season (see below). In 2014 the rains started in mid March (J. Denge pers. comm.), with nest-building and tending observed regularly throughout April; the first juvenile as seen on 17 May, 2.5 km west of Dida Hara, with a group of three juveniles on 18 May near Arbora. However, a nest with chicks heard begging was found a month later on 15 June, 3.5 km north of Arbora. Clearly, bush-crows breed in response to the onset of rain, but if conditions are favourable the breeding season can be prolonged. Given the continual and protracted care that groups show for juveniles, it seems probable that bush-crows produce only a single brood per season and that late nests represent either re-nesting attempts or inexperienced birds trying to breed.

A second, less intense rainy season between September and November (EWNHS 2001) also stimulates some breeding activity. On 17 November 2012, PFD, AJB & REG made two observations of nesting: the first 4 km east of Yabello, where a group of bush-crows was tending a nest, and the second on Soda Plain where a group was observed building a nest (it is, however, unclear whether or not bush-crows maintain nests year-round, and this observation may not represent evidence of breeding). On 19 and 20 November, a further three nests were being visited by bush-crows, two east of Dida Hara and one on Soda Plain (AJB, REG). On 28 October 2013, also on Soda Plain, a fledged juvenile was observed repeatedly being fed by 1–2 adults (NJC). We have also recorded courtship behaviour at this time of year (see below). Two of the 57 birds captured in May 2013 appeared to be immatures, which were probably raised in the second wet season of the previous year (AJB, SEIJ; see below).

Nest sites

Bush-crows construct large, crudely spherical or semi-cylindrical nests of thick thorny twigs,

surrounding a dung- and mud-lined inner chamber reached by a tunnel with an entrance in the upper part of the structure (Fig. 2, top). These are placed in the crowns of trees, the upper half sometimes sitting proud of the canopy (Benson 1942, Dellelegn 1993, Töpfer & Gedeon 2012, pers. obs.). Nests are usually built in *Acacia* spp., *Balanites aegyptiaca* or *Commiphora africana*, mostly between 3.0 and 6.5 m above ground (mean = 4.88 m: Töpfer & Gedeon 2012) and are normally solitary (Fry *et al.* 2002). However, we have several observations of two, one of four and one of seven nests in a single tree (Fig. 2, bottom), but we lack evidence of whether more than one nest was in use simultaneously. Nest height is necessarily limited by the height of the trees used; the highest nest of 210 around Dida Hara was 14 m above ground (Töpfer & Gedeon 2012). During transects across the range in 2013 and 2014, AJB found only 17 of 243 nests to be higher than 15 m above ground, with a mean height of 8.9 m, in trees with a mean height of 9.6 m. This compares to a mean tree height of 7.1 m across transects, suggesting that bush-crows preferentially select taller trees to nest in, presumably to allow them to gain extra height for the nest.

The use of man-made structures had not previously been reported, but we recently observed two such instances. On 26 October 2013, near Madacho, NJC found a nest on a power distribution pole *c*.7 m above ground: it was balanced on the metal cross-arm and apparently wedged between the top of the central pole and both the central cable and insulator (Fig. 3, top). None of the twigs appeared to be intertwined with any part of the powerline to hold the nest in place, and its vulnerability was evident from the substantial remains of an earlier nest (in two halves; or possibly two nests) below the same pole. The line ran through scattered trees of similar height and structure to others often used for nesting, and past some village huts; the nest itself was judged to be roughly as high as or possibly a little higher than the upper canopies of the adjacent trees. On 10 May 2014, west of the main road 29 km north-east of Yabello and only 6.5 km from the edge of the bush-crow's range, AJB found a nest on an electricity pylon. The nest was *c*.90% up the main tower, at a height of at least 25 m, making it by far the highest nest reported. It was supported by, but seemingly not secured to, the framework of the pylon. Two birds were seen visiting the nest (Fig. 3, bottom). The immediate vicinity again contained trees similar in height to those in which nests are frequently found, but these contained no nests.

The energetic costs of visiting the high pylon nest must be greater than for lower nests in trees (Zach 1979), and nesting on pylons may increase the risk to bush-crows from aerial predator attack. However, it is perhaps the case that the extra height better cools the nest, reducing heat-stress and perhaps increasing breeding success given the species' apparent temperature sensitivity (Donald *et al*. 2012, Töpfer & Gedeon 2012, 2014, Jones 2013). This might explain the difference in mean height of 4.88 m found by Töpfer & Gedeon (2012) and 8.9 m presented here, as the 2012 figure comes from Dida Hara, near the centre of the range, which is perhaps cooler on average than sites across the range, which produced the new, higher mean (Donald *et al*. 2012). Cooling might also explain why many nests in trees sit proud of the canopy.

Display

Gedeon (2006) described some display behaviours related to allofeeding, nest building and courtship. On 26 October 2013, just north of Soda Plain, NJC & PFD encountered two bush-crows that were remarkably confiding in their behaviour, first in a low tree and then on the ground, permitting the observers to approach within a few metres. On the ground one bird walked a few yards behind the other, with the observers quietly following them. After a minute

or so the bird following adopted a posture recalling a displaying male dove, in which it stretched its neck up and forward at *c*.45°, raising the crown feathers so that its head appeared larger (with seemingly an inflated bulge on the neck-sides), tilting the head forward so the bill pointed 30° downwards, exaggerating its steps so that they appeared slightly higher and slower, and fanning its tail to twice its usual width and tilting it downwards so that its tip dragged along the ground (Fig. 4). During this display, the fleshy patch behind the blue eye-ring was prominently displayed, and the eye appeared to be bulging and half-closed. This appeared to be a courtship display by a male to a female, but it might conceivably have been a mate-guarding display if the bird in question was somehow registering the human observers as threats to its mate or status. Gedeon (2006) recorded a similar display, except that the performer led rather than followed the second bird; he judged it to be a courtship display by a nest-building pair.

Gedeon (2006) noted that 'allofeeding and allopreening remained, as far as could be observed, unreciprocated'. However, on 24 May 2014, AJB observed two birds reciprocally allopreening (Fig. 5). These birds appeared to be a pair, perched in a separate tree and paid little attention to the rest of their group, so it may be that, although allopreening is widespread, reciprocation is limited to breeding pairs. Allopreening of juveniles by their attendant adults is also common.

Nestlings and juveniles

Benson (1942) described the eggs of Ethiopian Bush-crow when he collected two clutches (one of four eggs and one of six). On 14 June 2008 a few kilometres north of Dubluk, an occupied bush-crow nest was found in a tree so low that the nest chamber could be accessed by hand from the roof of a vehicle, by P. Dolman. It contained two naked and blind nestlings probably less than one week old, apparently the first time young in the nest have been photographed (Fig. 6). This nest was attended by at least five adults; four were seen to fly out of it in succession as it was approached, one of them carrying a faecal sac, which it smeared on the first branch of a nearby tree on landing.

Dellelegn (1993) and Fry *et al*. (2002) briefly described the differences between adult and juvenile plumage, in the field the most obvious of which are the grey-white tint to the juvenile head and neck feathers (which in adults are often brown-white, due to staining from the local soil; Fig. 7), and the dark skin around the eye (cobalt-blue in adults). Feathering covering the nares is duskier in young, creating (in conjunction with the dark ocular/loral skin) a dark 'saddle' over the bill (Fig. 8) and affording the juveniles (to some observers, at least) a striking similarity to the face of a common dolphin *Delphinus* sp.! Juveniles also display a distinctive pale pink bill base, and the gape is bright pink-red (Fig. 7). In late June 2014, juveniles a few weeks post-fledging were still readily distinguishable from adults when AJB left the study site.

Two birds captured on 6 May 2013 (SEIJ & AJB) near Madacho displayed characteristics of juveniles from a previous breeding season. Both had noticeably darker blue facial skin with the residual pink bill base (Fig. 9; compare top, a presumed subadult, with bottom, an adult). Notably, these birds were not recently fledged (judged by wear to the remiges and rectrices). These characteristics were observed on no other individual captured (n = 55) nor observed in the field.

Two calls were documented from juveniles, adding to the vocal repertoire of the species previously described by Dellelegn (1993) and Gedeon (2006). Young in the nest emit a constant soft and squeaky *kew*, recordings of which have been archived online (www.xeno-canto.org/131679, 131678). During the post-fledging period, young emit a series of loud and

insistent *kah* and *kew* notes, which are distinctly muffled during feeds, resembling the allofeeding *kaw kaw kaw* described by Gedeon (2006) (Fig. 10). These begging calls are similar to the juvenile contact call described by Dellelegn (1993), but the tone is sharper and the usage clearly for begging rather than contact. The calls are distinctive and almost constant during active periods, making location of post-fledging groups particularly easy. They have been documented and archived online (www.xeno-canto.org/140133, 140131).

We have, on a number of occasions, observed juveniles fanning their open wings, both while perched and on the ground (Fig. 11). This behaviour does not seem to be related to begging, and its function is unclear, but it is notable that we have observed it only in juveniles.

Morphology and moult

Biometrics

Biometric data have not previously been collated for the species, with quoted figures (e.g. mass of *c*.130 g) in Madge (2009) probably speculation. Table 1 presents biometrics of 57 live individuals trapped in the field and 14 specimens at the Natural History Museum, Tring, UK. Biometrics were examined for bimodality, but there was little evidence to suggest these are useful for sexing individuals. We also found a range of biometric values in individuals with well-developed brood patches. If these are presumed to be females, then the lack of biometric bimodality is supported, but it is possible that males assist with incubation, and develop brood patches too, although this is rare in corvids (Goodwin 1986). Biometric bimodality is recorded in other corvids, but with a sufficient degree of overlap between the distributions to present uncertainty if used alone for sexing individual birds (Fletcher & Foster 2010, Giammarino *et al*. 2012).

Table 1. Biometric summary of 57 Ethiopian Bush-crows *Zavattariornis stresemanni* trapped for colour-marking in 2013 and, except for last two variables, 14 specimens at the British Natural History Museum (NHMUK), Tring, UK.

	Birds caught in 2013 *n* = 57		NHMUK, Tring, specimens *n* = 14	
Value	**Mean ± 1 SD**	**Range**	**Mean ± 1 SD**	**Range**
Flattened wing chord (mm)	141.8 ± 3.7	135–149	141.4 ± 3.5	137–148
Tail (mm)	125.2 ± 5.6	108–135	125.0 ± 3.8	121–135
Culmen–skull (mm)	35.5 ± 2.0	31.1–41.1	34.2 ± 2.2	30.3–37.7
Head and bill (mm)	63.1 ± 1.9	59.5–67.5	65.6 ± 4.0	55.8–71.7
Maximum tarsus (mm)	45.2 ± 1.5	41.1–48.6	-	-
Mass (g)	109 ± 6.1	97–124	-	-

Feather and plumage morphology

Simple morphology was examined on trapped birds. Bush-crows have ten primaries, six secondaries and three tertials. Primaries 10–5 are emarginated. As in many corvids, the first

tertial (outermost from the body) is longer than the sixth secondary. There are 12 rectrices. Feathers were noticeably lightweight and low-density, particularly on the belly, breast, axillaries and crural areas (Fig. 12), which is interesting when considering the species' apparent climatically driven range-restriction (Donald *et al*. 2012). Perhaps light, low-density feathers serve to allow better heat dissipation for effective thermoregulation, in addition to the use of the exposable flange on the side of the head (Töpfer & Gedeon 2014).

Plumage aberrations have not been reported in the species previously, but once SEIJ observed a bird with a single leucistic primary (Fig. 13).

Moult

A high proportion of trapped birds (80%) were synchronously moulting and tending nests. Many of these were in an advanced stage of wing moult, indicating they had started their moult early in the breeding cycle. Moulting and breeding simultaneously is uncommon in birds, but has been reported in similar arid-zone species such as Pale-winged Starling *Onychognathus nabouroup* (Craig 2012) and Southern Pied Babbler *Turdoides bicolor* (A. Ridley pers. comm.), of which the latter also breeds cooperatively. Such synchrony may be driven by physiological stressors, such as high temperatures, which, if greater during the non-breeding season, necessitate moulting during the breeding season.

Remex moult patterns are centrifugal as to be expected in most passerines, beginning with the greater coverts and moving from the first primary outwards, with secondary moult probably starting simultaneously with pp4–6. A lack of apparent pattern, however, was observed in rectrix moult in a large proportion of trapped birds, where in some circumstances up to three generations of feathers were present (Fig. 14). The explanation is unclear, but is the likely cause of regular observations of bush-crows displaying a fork-tailed appearance in flight (Fig. 13). Rectrix moult was observed to be more uniform in some birds, however, commencing with the central pair.

The extent of post-juvenile moult is unknown, although both trapped individuals thought to be young from the previous season showed no moult limits or feather attributes normally associated with young birds (e.g. pointed tips to primary-coverts or rectrices). Considering the controlled and protected nest environment of the bush-crow (Benson 1942, Töpfer & Gedeon 2012), juveniles may be able to take more time to grow better-quality feathers than other passerines, which they then retain for a protracted period before moulting into subsequent plumage. While uncommon in a passerine, this strategy would offer more effective thermoregulatory ability under high temperatures that appear to restrict their behaviour (Jones 2013), and would reduce metabolic stress in already physiologically challenging conditions.

Group dynamics

Breeding groups

Bush-crows breed co-operatively and several helpers tend active nests, although their specific roles and fidelity to nests are unknown. Benson (1942) noted that it was usual for three birds to tend a nest, but that there was no evidence for more than one female laying. Donald *et al*. (2012) observed three nest helpers (additional to the breeding pair) at each of four nests, while observations by Gedeon (2006) suggest that helpers may tend several nests simultaneously. However, PFD has observed a group where helpers visited several crudely constructed nests in between visiting one that was clearly active, so an alternative explanation is that helpers build 'practice' nests while tending 'real' ones. The same apparent 'nest infidelity' was observed on a

couple of occasions by AJB & SEIJ in 2013 while observing colour-marked birds.

While undertaking behavioural observations on post-fledging groups (frequently containing colour-marked birds) in 2013 and 2014, SEIJ & AJB observed at least 24 groups across eight sites for protracted periods. Modal group size was 9–10 birds, comprising 2–6 adults (all appearing to possess some role in post-natal care) and 1–5 juveniles. The ratio of adults to juveniles in each group varied from 6:1 to 3:4, although roughly equal proportions were most common. The high adult to juvenile ratio serves to highlight the attentive post-natal care given to young birds by the group. The two smallest groups contained two adults and one juvenile. However, at least one of these groups was almost certainly not the product of bi-parental care as one of the adults had been caught and colour-marked attending a nest amongst a larger group. It is therefore possible that these observations pertain to birds defecting, or being expelled, from their original social group.

As noted by Gedeon (2006), these groups occasionally form larger flocks, or separate into sub-units while foraging, but the number of parent and tending birds appears stable within a group across multiple visits. While observing a nest in Dida Hara, KG observed a parent pair and two stable helpers, who were occasionally joined by a third individual. However, the latter was not well received by the parents, who even tried to prevent it from approaching the nest, perhaps indicating that genetic or social bonds may play a role in acceptance of helpers. Bush-crows are often observed playing with sticks, and the arrival of a bird at a nest with a stick is greeted by a cacophony of calling (Gedeon 2006; pers. obs.), suggesting that nest construction may be important in affirming group structure.

Non-breeding groups

During behavioural observations, SEIJ & AJB noted several small parties of up to eight adults (mode = 4–5) without chicks, with two observations of a lone adult. In 2013, many such groups included colour-marked individuals that had been trapped while attending nests, indicating that some helper birds may leave the group after the young fledge.

Post-breeding ranging behaviour

Active nests were identified at the time of ringing in 2013 by observing the birds' regular flight paths and nest visits. The dispersal area from the nest for up to five weeks after fledging was measured by SEIJ for four colour-marked groups, followed on at least three separate days over at least a two-week period (Table 2).

Table 2. Summary of group sizes, observation coverage and dispersal area for four post-fledging Ethiopian Bush-crow *Zavattariornis stresemanni* groups followed in 2013 by SEIJ.

Site	Group size (adult : juvenile)	Observation coverage	Total ranging area
Dida Hara	9 (4:5)	16 hours 29 minutes 5 days over 3 weeks	41.0 ha
Dida Tuyura	10 (5:5)	12 hours 33 minutes 4 days over 2 weeks	37.3 ha
Soda Plain	7 (4:3)	8 hours 40 minutes 3 days over 2 weeks	107.4 ha

Soda Plain	8 (4:4)	5 hours 43 minutes 3 days over 2 weeks	60.8 ha

These preliminary results indicate that at least some groups possess a high fidelity to the natal area. However, many groups with ringed birds were not relocated, particularly at the edge of the range near Dadim, where 18 birds were ringed but only two seen again during five days of searching. This is in keeping with reports given to KG, AJB & SEIJ by local people, in particular at the edges of the species' range, that birds are present in some seasons and absent in others, suggesting a degree of seasonal movement, as previously mentioned by other authors (Collar & Stuart 1985, Dellelegn 1993, Redman *et al*. 2009).

Visits to the region since the 2013 ringing season have provided further evidence for site fidelity. In April–May 2013 57 birds were ringed at four sites: Dida Hara (n = 17), Dida Tuyura (n = 6), between Soda Plain and Madacho (n = 16), and Dadim (n = 18). In October 2013 PFD, NJC & MW found nine ringed birds at Dida Hara and six on Soda Plain: of the latter, three could be individually identified, and all were within 1.5 km of where they had been caught. In April–June 2014, AJB observed nine ringed birds; at Dadim (n = 1), Dida Hara (n = 2), Dida Tuyura (n = 3) and Soda Plain (n = 3), all of which were within 2 km of where they were ringed in 2013. These observations were made during opportunistic rather than systematic searching, and overall more time was spent in areas where birds had been caught, meaning that any dispersers would be less likely to be detected. Nonetheless, the sightings provide evidence that some birds are strongly site faithful.

A single observation suggests that bush-crows may, occasionally, move around with other species. On 26 October 2013, PFD observed a single associating closely with a flock of Red-billed Buffalo Weavers *Bubalornis niger* (Fig. 15). When the flock was disturbed (presumably by an unseen raptor) and flew off far and high, the bush-crow accompanied them, despite the presence of a party of foraging bush-crows in the vicinity.

Interspecific interactions and behaviours

Predation

Gedeon (2006) reported observations of interspecific relations with potential predators, but to date known predators are few, although reports exist of a Tawny Eagle *Aquila rapax* opening the top of a nest (Collar & Stuart 1985) and an Eastern (Pale) Chanting Goshawk *Melierax poliopterus* successfully plundering a nest (Töpfer & Gedeon 2012). SEIJ observed a pair of Abyssinian Ground Hornbills *Bucorvus abyssinicus* apparently attempting to raid a bush-crow nest in May 2013, although this was some time after the young had fledged.

Predation of a bush-crow was observed for the first time by SEIJ on 3 June 2013. Widespread alarm behaviour by a post-fledging bush-crow group was elicited on detection of an Eastern (Pale) Chanting Goshawk, but the raptor managed to take a juvenile. On capture, the juvenile uttered a repeated distress call, attracting mass mobbing of the goshawk by other group members. This distress call was previously unknown, but first heard (and recorded) during the handling of birds in mist-nets (www.xeno-canto.org/140117).

Birds trapped in nets exhibited intriguing responses. Most initially gave the distress call described above, although some varied in their alarms, while a few remained relatively quiet. The distress call served quickly to attract other members of the group, many of which also were caught in the nets. After a short time, however, the remaining birds appeared to assess the

situation and would skilfully fly around or over the net, sometimes perching on it, and occasionally mobbing SEIJ & AJB as they extracted caught birds (Fig. 16). The distress calls acted as a stimulus to other species, commonly resulting in multiple-species captures, as was also the case from distress calls of other taxa.

Gedeon (2006) noted the confiding nature of bush-crows, which do not scare easily at the sight of people. However, SEIJ & AJB found that, while some groups are easy to approach to within 5 m, and will confidently forage around the feet of an observer, others are very wary, making approach closer than *c*.30–40 m difficult, with one or more birds alarming and causing the group to fly off. Both response extremes were exhibited by colour-marked birds, so this does not seem to be an artefact of handling; nor did the presence of juveniles in groups appear related to degree of wariness. Possibly it simply reflects individual 'personalities', with wary birds producing wary behaviour in their groups, but our overall impression was that groups that nest close to villages were much more habituated to people.

Antagonistic behaviour

We have observed bush-crows readily joining other species (most frequently Superb *Lamprotornis superbus* and White-crowned Starlings *Spreo albicapillus* and Red-billed Buffalo Weavers) in mobbing snakes including Puff Adders *Bitis arietans* on multiple occasions and a single cobra *Naja* sp. In 2013 SEIJ observed a bush-crow group harrying a domestic dog, and we have watched groups initiate the mobbing of Grey Kestrel *Falco ardosiaceus*, Gabar Goshawk *Micronisus gabar*, Tawny Eagle and Pearl-spotted Owlet *Glaucidium perlatum* in 2013 (SEIJ), and a perched Verreaux's Eagle Owl *Bubo lacteus* in 2014 (AJB); on the last occasion they were joined by single White-crowned and Superb Starlings. Despite this we found that bush-crows did not respond to artificial snakes or owls, which we attempted to use as lures to nets.

Bush-crows have also been observed to respond to benign species. In 2013 SEIJ observed groups mobbing innocuous targets such as a Cape Hare *Lepus capensis*, while KG has observed bush-crows taking an interest in large tortoises, hopping around them and even perching on their carapaces.

Nest proximity to other species

Bush-crows sometimes nest close to other species. In 2013 they were found nesting in the same tree as White-crowned Starlings on four occasions and among Red-billed Buffalo Weaver colonies on two, and once a single bush-crow nest was in the same tree as a Black-capped Social Weaver *Pseudonigrita cabanisi* colony (AJB). This would seem beneficial if the birds utilise one another's alarm calls for protection.

Other species sometimes use bush-crow nests. On 22 April 2013 SEIJ observed a pair of Shelley's Rufous Sparrows *Passer shelleyi* apparently tending an active nest in the base of an active bush-crow nest. On separate occasions in 2013, AJB witnessed a Superb Starling and a White-crowned Starling perched at the entrances of old bush-crow nests, and KG has observed both these species feeding their young inside old bush-crow nests.

Kleptoparasite avoidance

Gedeon (2006) briefly reported a bush-crow's avoidance of kleptoparasitism by a Northern Red-billed Hornbill *Tockus erythrorhynchus*. The bush-crow was digging at the ground with its bill to extract food. The hornbill approached and waited next to the bush-crow, seemingly ready to steal the prey. The bush-crow ceased digging and flew a few metres away where it 'pretended' to

forage. When the hornbill followed, the bush-crow quickly flew back to the first point, took the prey from the exact spot where it had previously dug, and flew away, apparently having deceived the hornbill.

Range boundary changes

The global range of the Ethiopian Bush-crow is relatively easily defined, owing to the abundance and conspicuous nature of nests in the tops of trees (Donald *et al*. 2012). A range of hills with unsuitable habitat was believed to define the limit of the species west of Yabello, despite a stretch of seemingly suitable habitat along the Yabello–Consu road immediately west of the hills and a single record from the area in 1983 (Collar & Stuart 1985). Benson (1946) reported that bush-crows were absent west of Yabello, and since 2005 we have often driven this road and never encountered the species or its nests. However, on 11 April 2014, AJB was taken along this road to an area of woodland north of the village of Arbora, 16 km north-west of Yabello. Here A. Huka, a local scout, had discovered bush-crows three weeks earlier. Thirty minutes of searching yielded three nests and at least two groups of birds. AJB returned to the area on four more occasions until the end of June, finding further nests and groups. Curiously the central area, which contained most of the nests, held birds on the earlier visits but not on later ones, when searching further afield led to the discovery of groups elsewhere including right next to the main road at Arbora itself (Fig. 17). Birds have remained in the area since then (last seen on 13 April 2015; S. Busuttil pers. comm.) and on 18 July 2014 a group was seen 5 km south of Arbora (J. Denge pers. comm.) but A. Huka, who has worked at Arbora for four years, had never seen bush-crows there before.

There are other areas at the edge of the range where we have found bush-crow nests but have never seen any birds (Fig. 18, e.g. the Das–Egder road in the south-east). This suggests that there may be some fluctuation at the edges of the range, which is of particular interest given the species' close-fitting climate envelope (Donald *et al*. 2012). If the birds are indeed limited by some temperature-driven stressor, range expansions perhaps occur in cooler years when the birds are able to survive further from their core range, and this is when nests are built in places such as Arbora and Borbor. In hotter years the birds retreat from these areas, leaving their robust nests, which evidently survive a number of years, as indications of their former presence. Our observations of the disappearance of large numbers of bush-crows post-breeding from the edge of the range offer further anecdotal support for this hypothesis.

Call for observations

Ethiopian Bush-crow is a fascinating and rewarding study species, and whilst our observations have revealed a suite of new behaviours, a great deal more remains to be learned. We would be interested to hear from anyone visiting the region who observes other under-described behaviours, and in particular to receive photographs, together with a date and rough coordinates, of any colour-marked birds, to aid our understanding of survival rates and dispersal behaviour.

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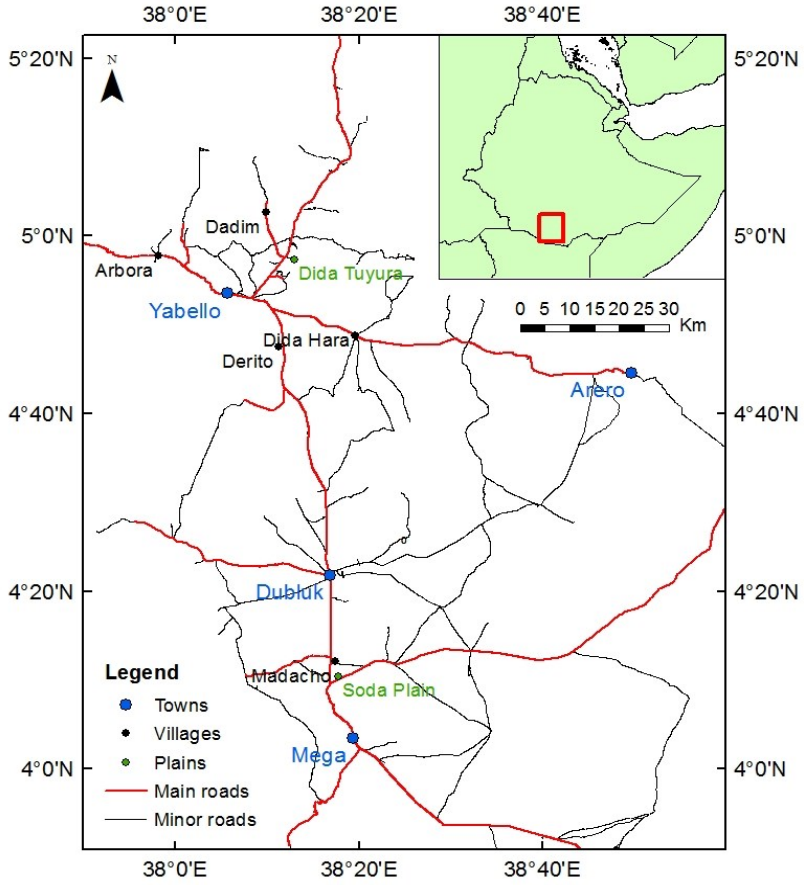

Figure 1. Map of the study region, showing the locations of sites referred to in the text. Inset: the location of the study region within Ethiopia.

Figure 2. Structure and location of Ethiopian Bush-crow *Zavattariornis stresemanni* nests: **(a)** the entrance to a nest found low in a tree; **(b)** a large *Acacia* containing seven nests (Claire N. Spottiswoode and Paul F. Donald)

Figure 3. The first reports of Ethiopian Bush-crows *Zavattariornis stresemanni* nesting on man-made structures: **(a)** nest on a power distribution pole found in October 2013; **(b)** active nest on an electricity pylon found in May 2014, high above the surrounding trees (Nigel J. Collar and Andrew J. Bladon)

Figure 4. Ethiopian Bush-crow *Zavattariornis stresemanni* displaying to another; stretching its head up and forwards, fanning its tail and exaggerating its steps (Paul F. Donald)

Figure 5. Colour-marked Ethiopian Bush-crow *Zavattariornis stresemanni* and its partner reciprocally allopreening (Andrew J. Bladon)

Figure 6. Ethiopian Bush-crow *Zavattariornis stresemanni* nestlings taken from a nest in June 2008, showing large, pale gape flanges typical of chicks raised in dark nests (Claire N. Spottiswoode)

Figure 7. Ethiopian Bush-crow *Zavattariornis stresemanni* family in an *Acacia*, permitting comparison of the differences in plumage between adults (right) and juveniles (Paul F. Donald)

Figure 8. Juvenile Ethiopian Bush-crows *Zavattariornis stresemanni* lack the cobalt-blue eye-ring of adults, instead possessing a black mask, darker feathering over the nares and a distinctive pale pink bill base; compare Fig. 9a (Sam E. I. Jones)

Figure 9. Comparison of the facial features of Ethiopian Bush-crows *Zavattariornis stresemanni*: **(a)** presumed subadult; **(b)** adult (Sam E. I. Jones)

Figure 10. Adult Ethiopian Bush-crow *Zavattariornis stresemanni* feeding a juvenile; the attendance of juveniles by the adults demonstrates the high levels of post-natal care (Andrew J. Bladon)

Figure 11. Young Ethiopian Bush-crow *Zavattariornis stresemanni* fanning its wings; the reason for this behaviour is not apparent (Paul F. Donald)

Figure 12. Typical light feathering observed on the belly, breast, axillaries and crural areas of Ethiopian Bush-crows *Zavattariornis stresemanni* (Sam E. I. Jones)

Figure 13. Ethiopian Bush-crow *Zavattariornis stresemanni* showing a single leucistic fourth primary; note the 'fork-tailed' appearance caused by rectrix moult, with the central pair dropped (see Fig. 14) (Sam E. I. Jones)

Figure 14. Peculiar rectrix moult present in many Ethiopian Bush-crows *Zavattariornis stresemanni* captured in 2013, showing heavy wear and three separate generations of rectrices (Sam E. I. Jones)

Figure 15. Solitary Ethiopian Bush-crow *Zavattariornis stresemanni* taking flight with a group of Red-billed Buffalo Weavers *Bubalornis niger* (Paul F. Donald)

Figure 16. An Ethiopian Bush-crow *Zavattariornis stresemanni*, perched on the mist-net shelf, investigates how to free its companion from the net (Sam E. I. Jones)

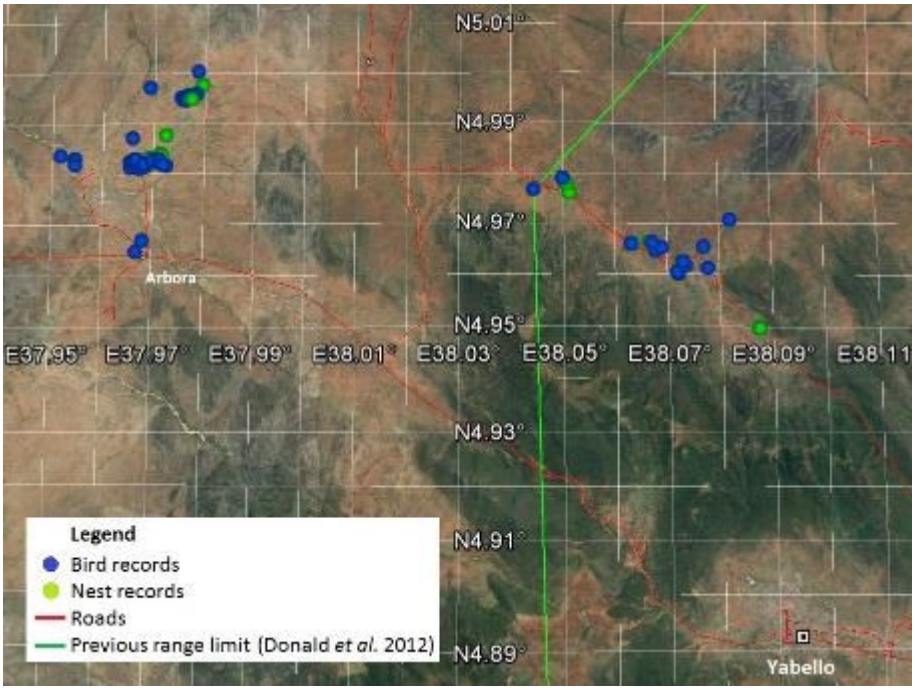

Figure 17. Locations of Ethiopian Bush-crows *Zavattariornis stresemanni* (blue dots) and their nests (green dots) found near Arbora in 2014 (western cluster). The eastern cluster contains records from 2014 and previous years, and the green line represents the previous range limit (Donald *et al.* 2012). Red lines represent roads. Source: GoogleEarth 4.942512° N and 38.028320° E. © 2015 Cnes/Spot Image. Image © 2015 DigitalGlobe. Imagery date: 02/02/15. Image accessed: 21/09/15.

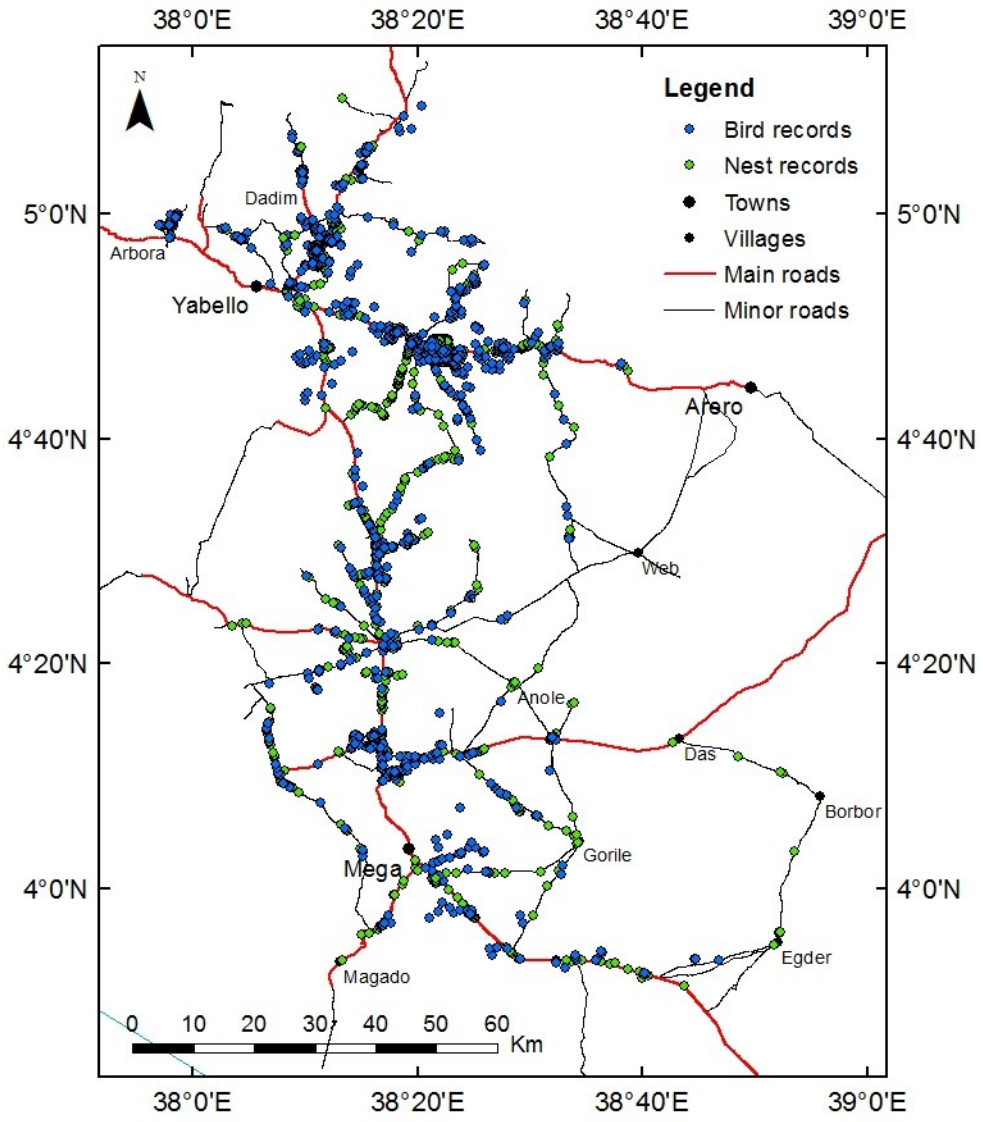

Figure 18. All Ethiopian Bush-crow *Zavattariornis stresemanni* records 2005–14, showing areas on the edge of the range where nests have been found, but birds have never been recorded.